3D PRINTED PMMA REPLICA OF DONOR TOOTH FUNCTIONING AS SURGICAL GUIDE IN-AUTO TOOTHTRANSPLANTATION – A CLINICAL STUDY

Dissertation submitted to

THE TAMILNADU Dr. MGR MEDICAL UNIVERSITY

In partial fulfillment for the Degree of

MASTER OF DENTAL SURGERY

BRANCH III

ORAL AND MAXILLOFACIAL SURGERY

MAY 2019

THE TAMILNADU Dr. M.G.R MEDICAL UNIVERSITY

CHENNAI

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation titled **"3D PRINTED PMMA REPLICA OF DONOR TOOTH FUNCTIONING AS SURGICAL GUIDE IN-AUTO TOOTHTRANSPLANTATION – A CLINICAL STUDY"** is a bonafide record and genuine research work done by me under the guidance of **Dr.B.VIKRAMAN, M.D.S.** Professor, Department of Oral & Maxillofacial Surgery, Ragas Dental College and Hospital, Chennai.

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CERTIFICATE

This is to certify that this dissertation titled **"3D PRINTED PMMA REPLICA OF DONOR TOOTH FUNCTIONING AS SURGICAL GUIDE IN-AUTO TOOTHTRANSPLANTATION –A CLINICAL STUDY– A CLINICAL STUDY"** is a bonafide record of work done by **Dr. DEEPAN.R,** under our guidance and to our satisfaction during his postgraduate study period **2016-2019.**

This Dissertation is submitted to **THE TAMILNADU Dr.M.G.R MEDICAL UNIVERSITY,** in partial fulfillment for the award of the Degree of **MASTER OF DENTAL SURGERY – ORAL AND MAXILLOFACIAL SURGERY, BRANCH III.** It has not been submitted (partial or full) for the award of any other degree or diploma.

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On verification with the unkund.com website for the purpose of plagiarism check, the uploaded thesis file from Introduction to Conclusion contains 9% of plagiarism, as per the report generated and it is enclosed in Annexure – II.

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ACKNOWLEDGEMENT

They say, when you have the Attitude of Gratitude, Express it. A heartfelt thanks to all who made this project possible.

*I bow down to the Omnipresent **Almighty God**, for showering His blessings upon me and being the Alpha and Omega of my life; His Amazing Grace gives me the strength for each day.*

*It is with great pride and honor that I express my gratitude to my Mentor, my Inspiration and Head of the Department **Professor Dr M Veerabahu**, for his guidance, concern, overwhelming knowledge and constant attention that has been a paddle throughout my post-graduation period. I am indebted to him for bringing out all the hidden talents in me and molding me to a person that I am today, without whose constant encouragement and assurance it would have not been possible for me to accomplish the tasks that I have done so far. Sir the time I spent with you was an enriching experience for me.*

*I sincerely thank our beloved Principal, **Professor Dr Azhagarasan**, for allowing us to use the scientific literature and research facilities of the college.*

*I am extremely grateful to my Guide and inspiration **Professor Dr .B.Vikraman** and I want to make a special note on you sir " **The Legend in 3D Reconstruction**" for his relentless guidance, precious timely advice, words of encouragement, valuable corrections, throughout my study. His way of explaining complex things with simple illustrations, discipline, and imparting courage has made me come a long way. His guidance towards this project is immense and was constant at each step of the way, without whose support it would*

have not been possible for me to complete my task. I thank him wholeheartedly for his guidance and support in helping me finish the project on time. The wealth of knowledge and experience that I gained from you Sir, I will cherish for a life time.

I extent my heartfelt gratitude to ***Professor Dr B Vikraman*** *for being a great teacher and philosopher, whose insights and teachings are second to none. I have been an admirer of his surgical skills, creative thinking, meticulous planning and passion to understand the latest technology. Sir, I am grateful to you for imparting some of these qualities in me. I learnt from you to appreciate all the aspects of life, keep things simple and be cheeky & humorous whenever possible. Sir, your motivation and guidance stirred up a lot of enthusiasm in me.*

I take this opportunity to thank our respected Professor ***Dr Malini Jayaraj****, for lending her help and guidance all throughout my post-graduation period. Her zeal to make the department better was displayed by her wonderful care for her beloved students. Her constant words of encouragement, reassurance and her loving, and kind nature were a great support to me.*

I am greatly indebted to ***Dr Radhika Krishnan****, Anesthesiologist for sharing and imparting her vast experience in medicine. I am thankful to her for being a person to look up to for suggestions and help whenever there was a need.*

Words aren't sufficient to thank ***Professor Dr Shankar****, for his generous and courteous support in the completion of the dissertation and throughout my education. His belief on my ability was very re-assuring and a constant source of inspiration.*

I sincerely thank ***Dr Sathyabama****, for helping me push boundaries in the strive for excellence leaving behind no stone unturned and helping me to understand my own abilities.*

I would fail in my duties if I don't thank my former teacher ***Dr Seema Alice Matthew*** *for all encouragement and support.*

I am truly grateful to ***Dr Satheesh****, Reader for his little bits of advice, every now and then which was of great importance upon looking back. His extended effort to push my limits to get the best out of me was great indeed. I wholeheartedly thank him for helping me to assist in the various cases which was a valuable experience for me. I am thankful to* ***Dr Saneem*** *for extending his knowledge and guidance at each step of the way. His reassurance was a constant source of encouragement.*

A Big 'thank you' to ***Dr James Bhagat*** *for being my teacher beyond measure. He was always giving a spark to my motivation right from my undergraduation days and* ***Dr Harish*** *for always building up and maintaining a cohesive environment and learning atmosphere for me in the department.*

I also thank all my teachers both past and present for their valuable contribution at each step of the way. It is by their blessings that I stand where I am today.

I generously thank my batchmates ***Dr Ajit.C, Dr Arun Vignesh, Dr Kishok, Dr Stephen, Dr Manoj*** *for their united support and, constructive criticism at every step and self-less cooperation during my post-graduation years in the institution. I wish them a successful carrier ahead.*

I thank my juniors, ***Dr Veeraragavan, Dr Alka, Dr Diana, Dr Arvind*** *for all their constant support and help throughout the college days. I thank my sub-juniors,* ***Dr***

Badruddin, Dr Abinaya, Dr Priyanka, Dr Hemavathy, Dr Priyadharshini, Dr Moni Vikshini *for all their help.*

I thank my seniors ***Dr Nirmal Tony, Dr Vivek, Dr Sriraman, Dr Yasmin, Dr Sailaja, Dr Murthi, Dr Sharif, Dr Senthil, Dr Narasimman, Dr Nambi, Dr Siva, & Dr Nirmal*** *for their guidance and corrections throughout my college days. .*

I thank all my friends and well-wishers, with special mention to ***Dr Sandhya, Mrs Suji,Dr Kishok, Mr.T.Nizamuddin , Mr.Vijay, Mr.Nishanth*** *who has been a pillar of support to me and* ***Mr.ElayaRaja,Mr.Pandi durai,Mr.Selva,Mr.Ramesh*** *who always help me with their encouragement.*

*I also thank my friends****,*** *, Dr vignesh, Dr mythily mr sarath ,mr mani whose friendship I have extended from my undergraduation days.and special thanks to ms* ***jasmine glaffiria*** *who has been my pillar of support.*

I take this opportunity to thank the Sisters of our Department Mrs. Deepa, Mrs. Laila, Mrs. Mala, Mr. Venugopal, Mrs. Malathi and other non-teaching staff.

Saved the best for the last. It is very difficult to put pen to paper in thanking my parents ***MR. RAGHUNATHAN*** *and* ***MRS.PUSHPA*** *for their sacrificial love and care they have shown towards me. Their relentless and selfless support in making me a better person everyday was there to be seen in me always. It is nothing but their guidance that has led me thus far. I thank my sister* ***MRS.SINDHU*** *and her husband* ***MR.RAMACHANDRAN*** *for being an anchor of support in my life and cute soul* ***DHANA LAKSHANA.*** *I am also thankful*

to my late grandpa ***Mr.soundharajan*** *whose footsteps I wish to follow, and also grandma* ***Mrs. Dhanabhagyiam*** *whose blessings are always with me.*

ABSTRACT

AIM

The aim of the study is to evaluate the feasibility of using stereolithographic model of donor tooth as the template for the preparation of receipient site for autologous tooth transplant

MATERIALS AND METHODS

- 5 teeth in a dry mandible were used in this study
- Medical CT Image data to 5 dry edentulous mandible obtained in DICOM format
- Using Mimics software 3dimensional reconstruction of donor tooth done and saved as STL format.(MIMICS - MATERALISE,BELGIUM)
- Replica of the donor tooth is printed with polymethyl metha acrylate with help of 3D injection moulding machine ,which acts as a surgical guide
- Surgical guide is used to prepare the new alveolor socket in the recipient site.

RESULTS

Visual comparison of the donor tooth and its replica showed no remarkable differences. The accuracy of the 3D model of pre-molar obtained by segmentation was compared with the 3D prototype model. The STL tooth model was used as a guide for a prior reshaping and proper matching between root surface of the donor tooth and recipient site.
The replica was fitted to make sure the donor tooth would fit exactly in the artificial tooth socket. The donor tooth was extracted with an elevator and forceps, while care was taken not to damage the cementum and apex of the tooth. Comparison of the donor tooth copy and the original tooth again showed no differences with regard to the shape of the root and crown in both cases. The mandibular third molar was placed at the site of the first molar and the right mandibular third molar was placed at the site of the second molar of the 3rd quadrant. The donor teeth were again placed in a slight infraocclusion. For both the left and right third molar, an immediate good fit at the recipient site was achieved with an extra-alveolar time of respectively one minute and nine seconds, and 53 seconds.

CONCLUSION

Selection of the optimal donor tooth and surgical procedure for reducing the damage of its periodontal ligament are essential for successful autotransplantation. Prior to autotransplantation,CT images and the 3D virtual simulation program helped recognise the risk anatomic structures, select the compatible donor tooth and predict the surgical process before

surgery. During the autotransplantation, the anatomic knowledge by simulation and CARP model could reduce the extra-oral time,number of attempts,surgeons intraoperative time and consequent damage to the periodontal ligament cells of donor teeth. The effective use of 3D technology can be helpful to improve the prognosis of autotransplantation,Recepient socket preparation is bit difficult for multirooted tooth

Key words: autotransplantation,recipient socket,dry mandibles,3D technology,CT images.

Introduction

INTRODUCTION

Autotransplantation is essentially a controlled avulsion and replantation, either into an extraction site or into a surgically prepared artificial socket (Natiella et al. 1970)[15]. Teeth autotransplantion can be defined as the placement of a tooth or tooth germ, with or without vitality, in a natural alveolus corresponding to another tooth, or in an artificially created alveolu for this end. (Escoda 1999; Donado 2007)[82].

It can be considered, in a wider concept of tooth autotransplantation for some authors such as Tsukiboshi, 3 distinct situations: First, when a tooth is extracted from a location and reimplanted in a different one, which is named tooth transplantation; Second, when a tooth is repositioned in its own alveolus, as in verticalization of 3rd molars or surgical extrusion of a tooth; Third, and finally, when an extracted or avulsed tooth is treated and reimplanted in its own location sometimes as an alternative to periapical surgery. (Tsukiboshi 2001)[9] This is a more global concept including intra-alveolar transplantation and intentional reimplantation, because all are characterized by a similar healing process. (Aslan, Ucuncu et al. 2010)[65].

The earliest reports of tooth transplantation involve slaves in ancient Egypt who were forced to give their teeth to their pharaohs. However, allotransplantation — transplantation of a tooth from one individual to another — was eventually abandoned because of problems of histocompatibility and replaced with autotransplantation. Autogenic transplantation of teeth was described

for the first time in the dental literature by the Swedish dental surgeon Vidman in 1915. Autogenous tooth transplantation was first well documented in 1954 by M.L. Hale[83]. The longevity and prognosis of tooth autotransplantation, especially with an immature root-formation donor tooth, are comparable to those with dental implants Andreasen et al. 1990c, Tsukiboshi 2001[9]. However, unfavourable survival rates (SRs) of autotransplanted teeth with complete root formation were reported (Kristerson, 1985, Andreasen 1992).[12] Furthermore, complications such as infection-related root resorption (inflammatory resorption) and ankyloses (replacement resorption) occur frequently in cases of donor tooth with complete root formation (Kristerson, 1985, Andreasen et al. 1990d).[13]

Andreasen et al. published a series of studies which clarified the prognosis and risk factors of tooth autotransplantation and proposed standard surgical procedures (Andreasen et al. 1990a,b,c,d)[12]. Success rates are found to be 90% or higher. Sugai followed 114 transplants and found a one- year success rate of 96%, with 84% at five years. Other studies have shown between 79 and 95% success rates, with follow-up times as long as 41years. Another recent study, by Bae, showed that high success rates (84%) can even be achieved with closed apex teeth and root canal treatment. These consistently high success rates are a contrast to the variable results reported in many older studies. Schwartz and others yielded success rates of only 76.2% at 5 years and 59.6% at 10 years. Similarly Pogrel found that his success rate

for 416 auto transplanted teeth was 72%. Yet, its success rate is still quite variable.

The majority of studies that evaluated autotransplantation treatment outcome focused on the biological perspective of treatment. Czochrowska et al[45] uniquely assessed patients'and professionals' perception to the aesthetic outcome of autotransplanted premolar teeth in the maxillary anterior region. The authors found that more than 80% of the patients and dental professionals rated their aesthetic treatment outcome as satisfactory or acceptable.

A successful autotransplant with a normally functioning periodontium will have proprioception and provide thermal feedback like the adjacent teeth. These teeth can be moved orthodontically using fixed orthodontic appliances. Finally they will preserve alveolar bone volume even in the event of failure of the auto transplanted tooth

Conventional surgical techniques involve a controlled, minimally traumatic extraction of the donor tooth. The tooth is then evaluated for root shape and number, returned to its original socket or placed in an appropriate storage medium. The failing tooth is then extracted, and the socket is prepared sufficiently to accommodate the donor tooth in the best possible position. The donor tooth is tried in the recipient socket with light pressure to establish whether the socket is prepared to an appropriate size. The socket should be prepared slightly larger than the tooth root and 1–2 mm deeper apically to preserve the PDL and allow space for vascular regeneration (Paulsen et al. 1995, Tsukiboshi 2002, Lon et al. 2009)[29]. Often, the tooth is seated slightly

below the occlusal plane, to avoid initial occlusal interference and to allow the tooth to erupt into a functional position bringing bone with it, and socket preparation should take this into consideration (Tsukiboshi 2002, Jonsson & Sigurdsson 2004)[29]

Successful autotransplantation relies extremely reliant on the skill of the operator in carrying out the surgical procedure which is effectively a planned avulsion and replantation, in an atraumatic method as much as possible. Kristerson and Lagerstro¨m reported that the teeth that went on the fail in their study were the ones that were to be removed from the donor sites . In the study by Andreasen et al.[35] it was found that several factors were significantly related to future development of pulpal necrosis in the transplanted tooth, including length of extra-alveolar period. Here it was found that when donor teeth stored extra-alveolar for <1 min, 7 out of 102 (7%), developed pulp necrosis, whilst teeth were stored for >1 min, 51 out of 258 (20%), would go on to develop pulp necrosis. Trauma during extraction and replantation will determine the level of mechanical damage to the PDL, and therefore, the number of viable cells left on the root for reattachment to the socket wall. Excessive trauma will lead to irreversible replacement resorption (ankylosis).

It is postulated that the use of a surgical template will assist socket preparation and will minimize the extra alveolar period of donor tooth and thus prevent unnecessary additional PDL trauma. . Various attempts were done to fabricate a template based on average tooth dimensions, enabling an

appropriate sized template to be used for assessment of the socket preparation (width and depth) prior to placement of the transplant tooth in the donor site. This template can be used to re-model the socket of the recipient site prior to extraction and autotransplantation. Kugelberg et al[43] reported the use of a selection of previously extracted and sterilised teeth as surgical templates. These previously extracted teeth would be sized against the preoperative radiograph of the donor tooth, and then the closest match would be used to prepare the recepient socket.Other surgical templates have been proposed and include casting models of the extracted teeth in cobalt chrome to aid effective sterilisation and the use of a series of preformed templates of brass or copper.

However, by creating a surgical template that is identical to the donor tooth, the recipient site can be closely contoured to fit and thereby allow the immediate placement of the transplant into the prepared socket. An accurately contoured recipient site ensures that there will be an optimal blood supply to promote revascularization if it has an immature apex, whilst the reduced handling of the donor tooth reduces the possibility of damage to the delicate periodontal ligament cells or Hertwig's root sheath. The fabrication of these surgical stents will help with respect to skill of the surgeon and the extra-alveolar time of removal and replantation.

The application of digital technology in dentistry is becoming more widespread. There is an increasing shift towards utilizing Computer Aided Designing (CAD)/Computer Aided Manufacturing (CAM) especially in implant dentistry.

Computed Tomography or CBCT can allow accurate three dimensional imaging and pre-surgical assessment of the transplant site and the donor tooth. Using the data, the surgeon can assess the proposed transplant site for bone height and width, proximity to surrounding structures e.g. the inferior dental canal and maxillary sinus and judge the best position of the donor tooth post-transplant. Rapid three dimensional prototyping is an engineering development which aims to create an accurate physical three dimensional model quickly from computerised data. Shahbazian et al[57].explored the use of CBCT to produce a replica of the donor tooth and concluded that an accuracy of 0.25 mm can be achieved. Others have reported on the production of individual tooth replicas based on spiral computed tomography or more recent CBCT imaging (Keightley et al. 2010)[39]

Lee et al.[26], reported the using measurements from conventional spiral CT to produce surgical templates for auto transplantation of teeth. They produced surgical templates in two ways, one from measurements taken from the CT image, and the template produced first in wax then cast in resin, and the other using a computer aided rapid 3D prototyping with a 3D printer to produce a surgical model in resin. These templates were used in adult patients to facilitate autotransplantation of desired teeth

The use of stereolithographic (STL) models can provide significant advantages in the diagnosis and treatment planning, but model accuracy is a major concern that needs to be investigated further to determine the applicability of this procedure in clinical practice

Aims & Objectives

AIMS AND OBJECTIVES

The The aim of the study is to evaluate the feasibility of using stereolithographic model of donor tooth as the template for the preparation of recipient site for autologous tooth transplant and the dimensional accuracy between the donor tooth and the printed 3D replica evaluated.

Review of Literature

REVIEW OF LITERATURE

O. SCHWARTZ, P. BERGMANN AND B. KLAUSEN (1985)[80] In a retrospective study of a sample of 291 autotransplantations of human teeth carried out by 27 oral surgeons over a period of 25 years, the clinically and radiologically available factors at the time of surgery were analysed with reference to their prognostic relevance Prognostically relevant factors related to loss of the transplanted teeth were determined by both univariate life-table analysis and multivariate Cox regression analysis. Of the 11 factors analysed in the Cox regression analysis, the following seemed to be prognostically relevant to loss or retention of the graft: developmental stage of the graft, age of the patient, donor tooth type, ectopia of the donor tooth, extraoral storage ofthe graft, and oral surgeon. In the present material, the prognosis of the grafts did not seem to be significantly influenced by such factors as prophylactic administration of antibiotics and fixation time. Using relevant parameters, it is possible to create a prognosis forecast for the individual patient.

K-E. KAHNBERG (1987)[19] The indications for autotransplantation of teeth in 45 patients have been analysed together with a follow-up of the success rate of surgery.Most of the transplants were mature teeth, 37 out of 51, with closed apex. The majority of transplantations were carried out in order to replace single tooth losses (40) but in 11 cases, the teeth were used as an

abutment in prosthetic rehabilitation. In 14 cases, an impacted tooth was transplant- ed to its normal position. The follow-up ranged from 3 months up to 10 years. No progressive root resorption has been observed so far; only 6 cases with slight surface resorption. Clinical signs of anchylosis were noticed in 4 teeth and shallow bone defects in 6 patients. Small- or medium-sized periapical destructions were observed in 4 cases The experiences so far achieved do encourage a more comprehensive use of the method to solve problems associated with oral rehabilitation, from both prosthodontic and orthodontic points of view.

J. 0. Andreasen,1 H. U. Paulsen, Z. Yu, T. Bayer4 and . Schwartz(1990)[5] The purpose of the present investigation was to determine the long-term prognosis of autotransplanted premolars with respect to tooth survival and pulpal healing. The material consisted of 195 patients aged 7 to 35 years, with a total of 370 autotransplanted premolars with observation period ranged from 1 to 13 years. Pulp healing as evaluated by sensibility testing and radiographic signs of partial pulp canal obliteration was usually verified 6 months after transplantation. Finally, in teeth with completed root formation, the use of burs with internal cooling and no extra-alveolar storage prior to transplantation seemed to increase the chance for pulpal healing The present study indicates, that the size of the apical foramen and possibly the avoidance of bacterial contamination during the surgical procedure are explanatory factors for pulpal healing.

Villari N, Fanfani F(1991)[32] The authors report their preliminary experience with the use of a new CT reconstruction program: Denta-Scan. Tomodensitometric studies of both the maxillary and the mandibular bones are actually mandatory for the planning of the correct implantation techniques. Denta-Scan, usually employed for CT studies in implantology and maxillo-facial surgery, suits to both pre- and postoperative evaluations. It provides accurate anatomical imaging, identifying details and landmarks which are helpful for surgical planning. Moreover, it allows TDM evaluation of bone structures, showing the presence of pathologic conditions potentially affecting the result of implantology. In the postoperative follow-up Denta-Scan allows to verify the correct positioning of the prosthetic implant, testing its integration in the bone structure as well as the rate of surgical failure.

Skoglund A, Hasselgren G.(1992)[72] Autotransplantation is a reliable treatment option for the replacement of missing teeth; however, there is a wide variation in reported survival rates. The purpose of this study was to evaluate the success and survival rate of premolar autotransplantation and to underline the importance of autotransplantation in the treatment of missing teeth. We present the treatment and follow-up of 63 premolar autotransplants in 44 patients. After transplantation under local anaesthesia, radiological and clinical follow-up showed a survival rate of 100%, ie all premolars were still functional. We conclude that autotransplantation of premolars is a reliable treatment method especially for agenesis. It is not difficult to perform and is

aesthetically superior and more cost-effective than other treatments, especially when orthodontic alignment is necessary.

Karolina Mikkelä Stange, Rune Lindsten and Krister Bjerklin (1994)[44] To investigate the long-term outcome of treatment of missing maxillary incisor teeth by transplantation of premolars, with special reference to aesthetics and patient satisfaction.: Twenty subjects who had undergone transplantation of premolars to themaxillary incisor area were recalled for follow-up varying between 12 and 22 years post-surgery. Twelve subjects presented for examination, including radiography and three subjects participated only by answering questions. Three reference groups—general practitioners, orthodontists, and lay people—evaluated the aesthetic results from photographs. Patient satisfaction was evaluated by interviews and OHIP-14.The mean age at transplantation was 12.3 years: 1 subject had been 20 years old and 11 were in the range of 9–14 years. Twelve to 22 years after autotransplantation, 5 subjects could not be reached: of the 15 who could be contacted, the survival rate was 15 out of 15. In the 12 subjects who presented for clinical examination, 11 out of the 12 transplants were assessed as successful. Nine transplants were restored with crowns and five had been recontoured with composite buildups. In one patient, no restorative treatment had been undertaken. The subjects were satisfied with the aesthetic result. Autotransplantation of premolars is an appropriate method for treatment of missing maxillary anterior teeth. Subjects with a transplanted tooth to the

maxillary anterior region perceive their oral health as good long term. **Lundberg T, Isaksson (1996)**[24] This open study was undertaken to investigate the outcome of autotransplanted teeth over a 6-year period. The subjects were 296 patients who underwent autotransplantation in the 6-year period September 1986-August 1992 and outcome was measured by considering root formation, occlusion, endodontal and periodontal complications. 18 patients were excluded because of inadequate notes or radiographs (n = 3) or because they were lost to follow-up (n = 15). The groups were divided into open apex and closed apex, and duration of follow up was 6 months-5 years. Aplasia was the indication for operation in 158 (77 percent) of the open apex group but only 10 (14 percent) of the closed apex group, whereas caries and associated disease was the most common in the latter (n = 45, 61 percent compared with 20, 10 percent). There were 24 complete failures, 12 in each group ($p < 0.01$). Only 7 teeth in total developed full roots, and 159 showed incomplete growth. In the open apex group 112 teeth were in occlusal contact and 4 were extracted for severe infraocclusion. In the closed apex group there were 10 cases of mild infraocclusion, none of which required treatment. There were 7 cases of pulp necrosis in the open apex group, 4 of which required extraction. Two teeth in the closed apex group were extracted for endodontic reasons. Only 1 tooth (in the closed apex group) had to be extracted for periodontal reasons. Autotransplantation is a reliable method with a good prognosis for donor teeth with both open and

closed apexes. The technique is applicable whatever the aetiology of the agenesis, and is worthy of consideration should there be a suitable donor tooth.

Barrett EJ, Kenny DJ. (1997)[68] Dental trauma represents one of the few situations where dentists are called upon to make unscheduled diagnostic and treatment decisions in an area that is outside their routine experience. Since patients who sustain an avulsion present infrequently, except in child-oriented or emergency-based practices, clinicians often make diagnostic and management decisions based upon their previous rare treatment experiences. Clinicians also rely on published guidelines for this aspect of their practice and expect these standards to be up-to-date and based on eurrent research information. None of the current protocols has been tested by a prospective longitudinal outcome study in humans. Nevertheless, current guidelines have become the standard for clinical practice around the world. An effort must be made to develop treatment protocols that are based upon the biological mechanisms that underlie periodontal wound healing

Slade, G.D. (1997)[49] Growing recognition that quality of life is an important outcome of dental care has created a need for a range of instruments to measure oral health-related quality of life. This study aimed to derive a subset of items from the Oral Health Impact Profile (OHIP-49)-a 49-item questionnaire that measures people's perceptions of the impact of oral conditions on their well-being. Secondary analysis was conducted using data from an epidemiologic study of 1217 people aged 60+ years in South

Australia. Internal reliability analysis, factor analysis and regression analysis were undertaken to derive a subset (OHIP-14) questionnaire and its validity was evaluated by assessing associations with sociodemographic and clinical oral status variables. Internal reliability of the OHIP-14 was evaluated using Cronbach's coefficient alpha. Regression analysis yielded an optimal set of 14 questions. The OHIP-14 accounted for 94% of variance in the OHIP-49; had high reliability (alpha = 0.88); contained questions from each of the seven conceptual dimensions of the OHIP-49; and had a good distribution of prevalence for individual questions. OHIP-14 scores and OHIP-49 scores displayed the same pattern of variation among sociodemographic groups of older adults. In a multivariate analysis of dentate people, eight oral status and sociodemographic variables were associated ($P < 0.05$) with both the OHIP-49 and the OHIP-14. While it will be important to replicate these findings in other populations, the findings suggest that the OHIP-14 has good reliability, validity and precision

Hupp JG, Mesaros SV, Aukhil I, Trope M.(1998)[74] A previous study evaluated the viability of dog periodontal ligament cells as indicated by tritiated thymidine uptake after extended storage in Hank's balanced salt solution and Conditioned Medium. The purpose of this study was to evaluate histologic healing following the identical storage parameters established in the earlier study. Additionally, for Conditioned Medium, matched pairs (teeth evaluated for tritiated thymidine uptake and transplanted teeth) were examined

in an attempt to correlate periodontal ligament vitality and healing. Forty-six extracted endodontically treated dogs' teeth were randomly grouped and stored in Hank's balanced salt solution or Conditoned Medium for 6,48, and 96 h and then transplanted into 6-, 48-, and 96-h sockets. The control group teeth were transplanted without storage into 6-, 48-, or 96-h sockets. After 6 months the dogs were killed and the teeth were prepared for histologic evaluation according to Andreasen. Complete healing, inflammatory root resorption, and replacement resorption were evaluated and compared. Overall, significantly better healing was observed for teeth stored in Conditioned Medium than for teeth stored in Hank's balanced salt soulution. Conditioned Medium was not significantly different from controls. Additionally, there was a positive correlation between periodontal ligament viability and healing for Conditioned Medium. These results confirmed the importance of periodontal ligament viability in successful replantation and the potential of Conditioned Medium as a storage medium for avulsed teeth.

Czochrowska EM, Stenvik A, Album B, Zachrisson BU. (2000)[73]

The published literature contains no comprehensive studies that compare the outcome of premolar autotransplantation to the maxillary anterior region with natural incisors in the same patients. This article describes the gingival and periodontal conditions around premolars transplanted to the maxillary incisor region, subsequent to restoration. Forty-five premolars autotransplanted to the maxillary incisor region in 40 adolescent patients were evaluated after a mean

observation period of 4.0 years. Mean age at surgery was 11.0 years. Established clinical criteria were used to assess tooth mobility, plaque and gingival indexes, probing pocket depth, and percussion. Recession and hyperplasia of interproximal gingival papillae were assessed according to a recently proposed index. Standardized radiography was used to evaluate presence of pathosis, pulp obliteration, root length, and crown-root ratios. Clinical variables for transplants did not differ from those of the natural incisors, except for increased mobility and more plaque in a few transplanted premolars. The interproximal gingival papillae adjacent to all transplanted teeth were normal or slightly hyperplastic. Radiographically, all transplants showed varying degrees of pulp obliteration, but no signs of pathosis. Crown-root ratios were similar for natural and transplanted teeth as were distances from cementoenamel junction to marginal bone. The overall status of the transplanted premolars and surrounding tissues indicated that this treatment modality may be recommended when maxillary incisors are missing in adolescents. In addition, tooth transplantation represents an inherent potential for bone induction and reestablishment of a normal alveolar process.

Lee SJ, Jung IY, Lee CY, Choi SY, Kum KY(2001)[27] The maintenance of healthy periodontal ligament cells in the donor tooth is one of the most important factors for successful tooth transplantation. This is achieved by minimizing the extraoral time during the surgical procedure. If a duplicate form of donor tooth could be obtained before extraction, it would be

possible to precontour the recipient alveolar bone compatible with the donor tooth, and thereby reduce the extra-oral time of the donor tooth. We obtained a three-dimensional image with the real dimensions of the donor tooth from a CT Highspeed Advantage, allowing a life-sized resin model of the tooth to be fabricated. From 22 clinical cases, we achieved an average total transplantation time of 7.7 min. The average distance between the transplanted root surface and the alveolar bone from 12 available cases was 0.87 mm at the mesial cervix, 0.91 mm at the mesial apex, 0.98 mm at the distal cervix and 1.16 mm at the distal apex on the postoperative radiographs. Clinical data indicate that computer-aided rapid prototyping may be of value in minimizing the extra-oral time and possible injury to transplanted tooth during the process of autotransplantation.

Czochrowska, E.M., Stenvik, A., Bjercke, B. and Zachrisson, B.U. (2002)[45] The literature contains no follow-up studies of transplanted teeth with mean observation times exceeding 10 years. This article describes long-term outcomes, including gingival and periodontal conditions, and the patients' attitudes about treatment and outcome. The material comprised all accessible patients in the files of the Department of Orthodontics, University of Oslo, Norway, on whom treatment had been performed at least 17 years ago (n = 28). Established clinical criteria were used to assess tooth mobility, plaque and gingival indexes, and probing pocket depth. Standardized radiography was used to evaluate the presence of pathology, pulp obliteration, and root length.

Similar recordings were obtained from the in situ tooth contralateral to the initial position of the grafted tooth. Criteria for determining treatment success were established. All patients responded to questions about their treatment using visual analogue scales. The mean age at surgery was 11.5 years, and the mean observation period was 26.4 years (range, 17-41 years). Of the 33 teeth transplanted in the 28 patients, 3 teeth were lost after 9, 10, and 29 years, respectively. Therefore, the 30 teeth in the 25 patients we examined yielded a survival rate of 90%. The success rate was 79% because 2 transplants had ankylosed, and 2 others failed to fulfill the proposed criteria. The patients generally responded very favorably regarding their perception of the treatment.Their only hesitation was related to some discomfort during surgery. It was concluded that survival and success rates for teeth autotransplanted when the root is partly developed compare favorably in a long-term perspective with other treatment modalities for substituting missing teeth.

Campelo LD, Camara JR(2002)[32] This article is a retrospective clinical analysis of implants placed with a flapless approach.Seven hundred seventy implants were placed in 359 patients to restore both completely edentulous and partially edentulous arches with fixed prostheses or removable complete dentures. Each patient was examined after 3 months, 6 months, 1 year, and then once every year. Prostheses were removed, if possible, and implant mobility was assessed, periapical radiographs were obtained, and periodontal probing was performed. Implants were considered failed if they

had mobility or pain, had to be removed, or if they showed more than 0.5 mm of bone loss per year and signs of active peri-implantitis. The cumulative success rate for implants placed using a flapless 1-stage surgical technique after a 10-year period varied from 74.1% for implants placed in 1990 to 100% at 2000.Since flapless implant placement is a generally "blind" surgical technique, care must be taken when placing implants. Angulation of the implants affected by drilling is critical to avoid perforation of the cortical plates, both lingual or buccal, especially on the lingual in the mandibular molar area and the anterior maxilla. There should be no problem if the patient has been appropriately selected and an appropriate width of bone is available for implant placement. There is a learning curve to every surgical procedure, after which it becomes routine. There are many advantages for the patient as well as for the surgeon, since the procedure is less time consuming, bleeding is minimal, implant placement is expedited, and there is no need to place and remove sutures.Flapless implant surgery is a predictable procedure if patient selection and surgical technique are appropriate.

Vrielinck L, Politis C, Schepers S, Pauwels M, Naert I. (2003)[34]

The zygoma implant has been designed for those situations where there is insufficient bone in the upper jaw, which would otherwise require onlay or inlay (sinus) bonegrafts. The aim of the study was to present and validate a planning system for implant insertion based on preoperative CT imaging. It allows the surgeon to determine the desired position of different kinds of

implants. Finally a customized drill guide is produced by stereolithography. In this study, zygoma, pterygoid and regular platform implants were used. The treatment protocol is validated through 12 case studies, selected at random from the total patient group (n=29 patients). From postoperative images, the exact implant location is determined and the deviation of axes between planned and inserted implants is calculated. In this in vivo study, displacements, varying according to the type of implant and the location of the implants, were observed. From a clinical standpoint, most of the inserted implants were judged to be adequately sited. A prospective clinical follow-up study was performed on all 29 patients. Although all patients presented with severe maxillary atrophy, excellent cumulative survival rates (92%) for the zygoma implants and 93% for regular platform implants have been obtained.

Goiato MC, Santos MR, Pesqueira AA, Moreno A, dos Santos DM, Haddad MF. (2004)[43] Techniques of rapid prototyping were introduced in the 1980s in the field of engineering for the fabrication of a solid model based on a computed file. After its introduction in the biomedical field, several applications were raised for the fabrication of models to ease surgical planning and simulation in implantology, neurosurgery, and orthopedics, as well as for the fabrication of maxillofacial prostheses. Hence, the literature has described the evolution of rapid prototyping technique in health care, which allowed easier technique, improved surgical results, and fabrication of maxillofacial prostheses. Accordingly, a literature review on MEDLINE (PubMed) database

was conducted using the keywords rapid prototyping, surgical planning, and maxillofacial prostheses and based on articles published from 1981 to 2010. After reading the titles and abstracts of the articles, 50 studies were selected owing to their correlations with the aim of the current study. Several studies show that the prototypes have been used in different dental-medical areas such as maxillofacial and craniofacial surgery; implantology; neurosurgery; orthopedics; scaffolds of ceramic, polymeric, and metallic materials; and fabrication of personalized maxillofacial prostheses. Therefore, prototyping has been an indispensable tool in several studies and helpful for surgical planning and fabrication of prostheses and implants.

Mejare B, Wannfors K, Jansson L. (2004)[25] The study objective was to evaluate the prognosis for autotransplantation of third molar teeth with fully developed roots followed by endodontic treatment on the basis of a time-table analysis.A total of 50 third molars with completely developed roots were autotransplanted to replace a lost first or second molar in the same number of admitted patients. Root canal treatment was started 3 to 4 weeks later. Clinical and radiographic checkup of the transplanted and root-filled third molars was done annually according to a predesigned record form. Descriptive statistics including a life table and statistical analysis were performed. The cumulative survival rate during 4 years' follow-up was 81.4%. In all, 7 transplants were lost during the follow-up time, 4 of them due to marginal periodontal pathosis and the other 3 due to root resorption. None of the root resorptions was

observed before the second postoperative year. The radiographic periapical status was considered normal in 96% of the transplants at the latest follow-up. Autotransplantation of mature third molar teeth is a reasonable treatment alternative to conventional prosthetic rehabilitation or implant treatment in cases of partial edentualism from both a therapeutic and an economic point of view

Jonsson T, Sigurdsson TJ (2004)[38] This article describes the long-term outcome of 40 consecutive patients having transplanted premolars. The objective of this ongoing study is to investigate survival rate, pulp survival rate, periodontal condition, and root development of autotransplanted premolars in orthodontic patients. This report covers 17 years; 32 orthodontic patients had 40 premolars transplanted into contralateral or opposing jaw quadrants where a premolar was missing. The teeth were examined systematically with clinical and radiographic measures at 1, 2, 6, 12, and 60 months or more after autotransplantation. The observation time varied from 2 years 5 months to 22 years 3 months, with a mean of 10 years 4 months. Bonded.018-in edgewise appliances were used, subjecting 87.5% of the transplanted teeth to normal orthodontic forces. One tooth was removed because of root fracture during the observation period, and 2 more had complications possibly related to the transplantation. The remaining 37 teeth and their supporting structures were all healthy at the last examination--a 92.5% success rate. Transplants with closed apices received endodontic

therapy, but, in those with open or half-open apices, a 66% pulp survival rate was observed. No teeth in the sample had signs of replacement resorption or developed periodontal attachment loss. Inflammatory resorption in 2 teeth was arrested after endodontic treatment. Root formation, when not complete, continued on transplanted teeth, giving normal root form and adequate root length for normal function. It is concluded that autotransplantation of premolars combined with orthodontic treatment should be the first treatment alternative in cases of missing premolars, when a suitable donor tooth is available.

Kim E, Jung JY, Cha IH, Kum KY, Lee SJ.(2005)[26]

Autotransplantation is a viable option for treating missing teeth when a donor tooth is available. The aim of this study was to evaluate the prognosis in addition to the causes of failure in 182 autotransplanted teeth. A total of 182 cases of autotransplantation were analyzed. All the transplants were performed according to a computer-aided rapid prototyping technique with an average extraoral time of 7.58 minutes. These cases were followed for 2 to 60 months after surgery. The prognosis was divided into 4 groups, complete healing, incomplete healing, uncertain healing, and failure. The initial stability, root resorption, and ankylosis were also analyzed. Most transplanted teeth showed complete healing between postoperative 2 months and 8 months. The transplanted teeth with a good initial stability showed better initial healing than those with a poor initial stability. The average extraoral time was 7.58

min (range: immediately after extraction up to 25 min). There was no relationship (P > .05) between the extraoral time and either root resorption (4 cases, 2.4%) or ankylosis (18 cases, 10.7%) within this experimental time period. Nine cases (4.5%) failed. This study showed a 4.5% failure rate during the short to intermediate observation period. Autotransplantation is a very useful method for replacing missing teeth, provided that the extraoral time and other factors are well controlled.

Loubele M, Van Assche N, Carpentier K, (2008)[76] To compare the accuracy of cone-beam computerized tomography (CBCT) and multislice CT (MSCT) for linear jaw bone measurements.An ex vivo formalin-fixed human maxilla was imaged with both CBCT (Accuitomo 3D; Morita, Kyoto, Japan) and MSCT (4-slice Somatom VolumeZoom and 16-slice Somatom Sensation 16; Siemens, Erlangen, Germany). The MSCT images were reconstructed using different reconstruction filters to optimize bone visualization (U70u and U90u for VolumeZoom, H30s and H60s for Sensation 16). Before scanning, triplets of small gutta-percha markers were glued onto the soft tissues overlying the maxillary bone on the top and on both sides of the alveolar ridge to define a set of reproducible linear measurements in 11 planes. Image measurements were performed by 2 observers. The gold standard was determined by means of physical measurements with a caliper by 3 observers.The accuracy of the linear measurements was 0.35 +/- 1.31 mm (U70u) and 0.06 +/- 1.23 mm (U90u) for the Somatom VolumeZoom, 0.24 +/-

1.20 mm (H60s) and 0.54 +/- 1.14 mm (H30s) for the Sensation 16, and -0.09 +/- 1.64 mm for the Accuitomo 3D. Statistical analysis with 2-way analysis of variance showed no significant inter- or intraobserver disagreement for the physical or the radiologic measurements. There was also no significant difference for the measurements on the different reconstruction filters.Both CBCT and MSCT yield submillimeter accuracy for linear measurements on an ex vivo specimen.

Tanaka et al (2008)[44] In this study only premolar donor teeth were transplanted in orthodontic patients. there was no sacrifice of premolars in the patients. the donor premolars were transplanted to the site of maxillary anterior teeth. After classifying the 28 donor premolars into three stages of root development, all transplanted teeth were checked at a chair-side observation during the latest appointment. all donors were well-maintained in occlusion and presented a normal periodontal condition for an extensive follow-up.

M. Shahbazian, R. Jacobs, J. Wyatt†, G. Willems, V. Pattijn, E.Dhoore, C. Van Lierde & F. Vinckier(2010)[58] The aim of this study were to determine the accuracy of a 3D computer model and stereolithographic (STL) replica when compared to the real tooth and to develop a cone beam computed tomography (CBCT)-based planning technique including surgical guide fabrication To validate this process, tooth segmentation and replica design were prepared for comparison to an optical scan of the corresponding

tooth. For surgical intervention, a dry dentate mandible was scanned using a Scanora CBCT and the donor tooth was segmented These tooth replica and guides were used in socket preparation of the dry mandible. The 3D computer model of the segmented teeth and related STL models showed satisfactory results with an acceptable accuracy m allowing optimization of the STL models for in vivo planning of CBCT-based autotransplantation. Stereolithographic surgical guidance in autotransplantation may allow it to become more efficient and predictable treatment method for tooth replacement.

Honda(2010)[59] A 33yr old man was reffered by the local dentist for autotooth transplantation of right mandbular third molar to be transplanted to left mandibular first molar before thr procedure cone beam computed tomography was performed to asses the volume of tooth and the bone ..3D printed tooth is made with steriolithography by CAD/CAM technology and the recipient site is prepared with the help of the replica 3D printed tooth this reduced the extraalveolar time and the prognosis was good .The postoperative autotoothtransplantation was good.

Ewa M. Czochrowska, DDS,a Arild Stenvik, DDS, PhD,b Bjørn Album,c and Bjørn U. Zachrisson, DDS, MSD, PhDd(2010)[73] The published literature contains no comprehensive studies that compare the outcome of premolar autotransplantation to the maxillary anterior region with natural incisors in the same patients. This article describes the gingival and

periodontal conditions around premolars transplanted to the maxillary incisor region, subsequent to restoration. Forty-five premolars autotransplanted to the maxillary incisor region in 40 adolescent patients were evaluated after a mean observation period of 4.0 years. Mean age at surgery was 11.0 years .The overall status of the transplanted premolars and surrounding tissues indicated that this treatment modality may be recommended when maxillary incisors are missing in adolescents. In addition, tooth transplantation represents an inherent potential for bone induction and reestablishment of a normal alveolar process.

Kvint et al (2010)[39] This paper studied the autotransplantation of teeth in 215 patients who have undergone 269 teeth transplants by the same surgeon. 81% of the transplantations were recorded successful, 19% as unsuccessful, 25 have been extracted and 15 have survived but did not meet the criteria for success. Cases were marked as unsuccessful if the tooth was extracted or was surviving but with root resorption or ankyloses. ‘’many factors influence the results, such as the developmental stage of the tooth, donor type, duration of extra oral exposure of the tooth after surgery, damage to the root cementum and the periodontal ligament, and the experience of the oral surgeon.’’ The success rate is reported to be over 80% when the root length of the auto transplanted premolar is 50 to 75% of the normal root length at the time of surgery. Also, according to them, a lower predictor of success was patient age greater than 20years.

G. Budzik, M. Oleksy, M. Grzelka (2010)[77] The article discusses the possibilities of using optical measurements for defining the geometric accuracy of gear wheels casts manufactured in the rapid prototyping process. The tested gear wheel prototype was cast using an aluminum alloy. The casting mould was made by means of the three-dimensional print method (3DP) with the use of a Z510 Spectrum device. The aim of the tests was to determine the geometric accuracy of the cast made by the ZCast technology in the rapid prototyping process. The tests were conducted with the use of the coordinate optical measuring method and a GOM measuring device. The prototype measurements were made in the scanning mode. The results of the measurements, saved in the STL format with the use of the scanning device software, were compared with the gear wheel 3D-CAD nominal model. The measurements enabled the determination of the real accuracy of prototypes manufactured in casting moulds by means of the ZCast technology. The selection of the measuring method was also analyzed in terms of measurement accuracy and the RP technology precision.

Yan, Q., Li, B. & Long, X. (2010)[4] Tooth autotransplantation is a useful surgical method to replace a nonrestorable tooth. We reported our experiences in the replacement of mandibular nonrestorable molars by immediate autotransplantation in a Chinese population. Thirty-five mandibular third molars with open or closed apices from 34 patients were autotransplanted into the same or contralateral fresh recipient sites immediately after the

extraction of the nonrestorable mandibular molars. Root canal treatment was routinely performed in the closed-apical molars within 1 month after surgery. Clinical and radiographic examination of the transplanted donor molars was done after surgery. Two teeth were been extracted for progressive root resorption. The remaining 33 autotransplanted teeth were asymptomatic and functioning after a mean follow-up period of 5.2 years. No infection, ankylosis, loss of the transplants, or root resorption was noted in the remaining autotransplanted teeth. Immediate autotransplantation of the mandibular third molar is a reasonable and alternative treatment to replace a nonrestorable tooth in China.

Keightley AJ, Cross DL, McKerlie RA, Brocklebank (2010)[40]

Autotransplantation of immature teeth has good survival rates, and has benefits over ossointegrated implants in the growing child, but is very technique sensitive. Spiral CT imaging has been previously used in adult patients to enable computer-aided prototyping to produce a surgical template of the donor tooth, further increasing success rates.The case presented describes management of a 9-year-old girl with the combination of hypodontia affecting the upper lateral incisors as well as a severely ectopic maxillary canine. Cone beam CT was used in combination with computer-aided prototyping to produce a surgical template of an immature mandibular second premolar. The surgical template was used to prepare the transplant site before the donor tooth was extracted, greatly reducing the time from extraction to

implantation. By 6 months posttransplant the tooth was clinically sound, and continued root development and laying down of dentine was visible radiographically.This paper demonstrates the use of a novel technique to aid the surgical procedure of autotransplantation of immature premolar teeth. The use of autotransplantation in this case allowed the difficult situation of two missing units in the upper left quadrant to be reduced to one unit, while retaining symmetry in the upper arch. Compared to previous studies, the use of cone beam CT to create a 3D prototype reduced radiation dose compared to spiral CT and drastically reduced the extra-oral time of the donor tooth from extraction to transplantation.

Sugai, T., Yoshizawa, M., Kobayashi, T., Ono, K., Takagi, R., Kitamura, N., Okiji, T. and Saito, C. (2010) [54] Autotransplantation is often performed to replace a missing tooth, but tooth autotransplantation has been reported in fewer teeth with complete root formation than those with incomplete root formation. The aim of this prospective study was to evaluate the factors that affect the prognosis of autotransplantation of teeth with complete root formation. 109 patients with 117 transplants were studied. Of the 117 transplants investigated, 14 (12%) failed during the observation period. The overall 1-year survival rate was 96%; the 5-year survival rate was 84%. The major causes of failure were unsuccessful initial healing and replacement root resorption with periodontal inflammation. Factors significantly associated with unsuccessful transplantation, in single factor

analysis, were age 40 years or more, molar tooth as donor, probing pocket depth to 4mm or more, history of root canal treatment, multi-rooted teeth and fixation with sutures. Pocket depth of 4mm or more and history of root canal treatment appeared to increase the risk of unsuccessful transplantation in multivariate analysis. It is suggested that the pocket depth of the donor tooth and history of root canal treatment are related to the healing of paratransplantal tissue and root resorption.

Rengier F, Mehndiratta A, von Tengg-Kobligk H et al (2010)[42]

Generation of graspable three-dimensional objects applied for surgical planning, prosthetics and related applications using 3D printing or rapid prototyping is summarized and evaluated.Graspable 3D objects overcome the limitations of 3D visualizations which can only be displayed on flat screens. 3D objects can be produced based on CT or MRI volumetric medical images. Using dedicated post-processing algorithms, a spatial model can be extracted from image data sets and exported to machine-readable data. That spatial model data is utilized by special printers for generating the final rapid prototype model. Patient-clinician interaction, surgical training, medical research and education may require graspable 3D objects. The limitations of rapid prototyping include cost and complexity, as well as the need for specialized equipment and consumables such as photoresist resins. Medical application of rapid prototyping is feasible for specialized surgical planning

and prosthetics applications and has significant potential for development of new medical applications.

Orentlicher G, Abboud M. (2011)[31] New three-dimensional diagnostic and treatment planning technologies in implant dentistry have expanded on concepts of a team approach to the planning and placement of dental implants. The accurate and predictable placement of implants according to a computer-generated virtual treatment plan is now a reality, taking the virtual plan from the computer to the patient clinically. Recent advances in three-dimensional imaging in dentistry, in combination with the introduction of third-party proprietary implant planning software and associated surgical instrumentation, have revolutionized dental implant diagnosis and treatment and created an interdisciplinary environment in which communication leads to better patient care and outcomes.

Vilhjálmsson, V. H., Knudsen, G. C., Grung, B., and Bårdsen, A. (2011)[50] To investigate the indications for, and the outcome of auto-transplantation of teeth to the anterior maxillary region. MATERIAL AND METHODS: From 1978 to 1994, 41 teeth in 31 subjects were transplanted to anterior maxillary sites at the Department of Oral Surgery, Stavanger University Hospital, Norway. All transplantations were performed by one oral surgeon (B.G.). Relevant information was collected from patients' files, including radiographs of the tooth graft, the recipient site and follow-up radiographs. The mean observation period was 55.1 months (range 1-158

months). The age of the patients at the time of the auto-transplantation ranged from 10 to 30 years (mean 14.8 year). The most common indications for auto-transplantation were aplasia (41.5%), sequelae of trauma (36.6%) and impacted or ectopic teeth (17.1%). Eight teeth were judged to be failures; five had been extracted because of severe root resorptions and periodontal infection and three were judged as failures owing to severe ongoing root resorption but remained in the alveolus.Trauma is as common indication as aplasia for transplantation. From a biological point of view, dental auto-transplantation to the anterior maxillary region has a high success rate. Hence, auto-transplantation is an important treatment option for missing or lost maxillary anterior teeth where preservation of the alveolar bone is important during growth and development in adolescents. The major reason for failure was various types of root resorptions, some of which were detected late.

T. Tsurumachi1 & T. Kuno2 (2011)[30] To present the combined endodontic, surgical and orthodontic treatment of an autotransplanted maxillary first premolar for the replacement of an ankylosed maxillary incisor. his case demonstrates that autotransplantation of a maxillary premolar may provide the potential to replace an ankylosed anterior tooth with a natural tooth instead of a prosthesis or osseointegrated implant even following the removal of the buccal root. At a 7-year follow-up, the transplanted first premolar was clinically healthy and continued to satisfy aesthetic and functional demands.

Muhamad AH, Azzaldeen A(2012)[66] Autotransplantation of tooth in children is the surgical movement of a tooth from one place in the mouth to another in the similar individual. Once thought to be uncertain, autotransplantation has achieved high success rates and is an outstanding option for tooth replacement in children. Although the indications for autotransplantation are narrow, careful patient assortment coupled with a suitable method can lead to exceptional esthetic and useful results. One benefit of this procedure is that placement of an implant-supported prosthesis or other form of prosthetic tooth replacement is not needed. A review of the recommended surgical technique as well as success rates is also discussed.

Rusanen, J., Silvola, A.S., Tolvanen, M., Pirttiniemi, P., Lahti, S. and Sipilä, K. (2012)[60] The aim of this study was to examine the pathways between temporomandibular disorders (TMDs), occlusal characteristics, facial pain, and oral health-related quality of life in patients with severe malocclusion. The study comprised 94 (34 men and 60 women, mean age 38 years) adult patients who were referred for orthodontic or surgical-orthodontic treatment. All the patients had severe malocclusion. Oral health-related quality of life was measured with the Oral Health Impact Profile-14 scale (OHIP-14), the intensity of facial pain using a Visual Analogue Scale (VAS), TMD with Helkimo's clinical dysfunction index (Di), and occlusal characteristics with the Peer Assessment Rating (PAR). A hypothetical model of the interrelationships between these factors was constructed based on the conceptual model of

biological, behavioural, and psychosocial consequences of oral diseases. The associations were studied with path analysis. Women reported poorer oral health-related quality of life, higher pain levels, and had more severe TMD than men, but the gender difference was statistically significant only in pain and TMD. In contrast to the hypothetical model, among women the occlusal characteristics were not directly associated with oral health-related quality of life or facial pain. Among men, the occlusal characteristics were directly associated with oral health-related quality of life. In conclusion, patients with severe malocclusion who also have TMD and facial pain more often have impaired oral health-related quality of life. The associations of the occlusal characteristics with oral health-related quality of life differ between genders. Therefore, these associations should be studied separately among genders.

T. Traini, C. Mangano, R.L. Sammons, F. Mangano, A. Macchi, A. Piattelli (2012)[75] Statement of Problem. Direct metal laser sintering (DMLS) is a technology that allows fabrication of complex-shaped objects from powder-based materials, according to a three-dimensional (3D) computer model. With DMLS, it is possible to fabricate titanium dental implants with an inherently porous surface, a key property required of implantation devices. Objective. The aim of this review was to evaluate the evidence for the reliability of DMLS titanium dental implants and their clinical and histologic/histomorphometric outcomes, as well as their mechanical properties. Materials and Methods. Electronic database searches were

performed. Inclusion criteria were clinical and radiographic studies, histologic/histomorphometric studies in humans and animals, mechanical evaluations, and in vitro cell culture studies on DMLS titanium implants. Meta-analysis could be performed only for randomized controlled trials (RCTs); to evaluate the methodological quality of observational human studies, the Newcastle-Ottawa scale (NOS) was used. Results. Twenty-seven studies were included in this review. No RCTs were found, and meta-analysis could not be performed. The outcomes of observational human studies were assessed using the NOS: these studies showed medium methodological quality. Conclusions. Several studies have demonstrated the potential for the use of DMLS titanium implants. However, further studies that demonstrate the benefits of DMLS implants over conventional implants are needed.

Day PF, Lewis BR, Spencer RJ, Barber SK, Duggal M.(2012)[15]

Surgical trauma and prolonged extra-alveolar exposure of the donor tooth's root sheath are both complicating factors during tooth autotransplantation surgery. This case report describes a 12-year-old female patient who underwent surgical transplantation of a maxillary second premolar to a central incisor site. A three-dimensional printed analogue of the donor tooth was fabricated from a cone beam (CBCT) scan of the tooth in order to minimise the extra-oral (exposure) time and frequency of trial insertions of the donor tooth into the recipient socket. The laboratory and clinical aspects of this novel technique are described**.**

Rusanen, J., Silvola, A.S., Tolvanen, M., Pirttiniemi, P., Lahti, S. and Sipilä, K. (2012)[6] The aim of this study was to examine the pathways between temporomandibular disorders (TMDs), occlusal characteristics, facial pain, and oral health-related quality of life in patients with severe malocclusion. The study comprised 94 (34 men and 60 women, mean age 38 years) adult patients who were referred for orthodontic or surgical-orthodontic treatment. All the patients had severe malocclusion. Oral health-related quality of life was measured with the Oral Health Impact Profile-14 scale (OHIP-14), the intensity of facial pain using a Visual Analogue Scale (VAS), TMD with Helkimo's clinical dysfunction index (Di), and occlusal characteristics with the Peer Assessment Rating (PAR). A hypothetical model of the interrelationships between these factors was constructed based on the conceptual model of biological, behavioural, and psychosocial consequences of oral diseases. The associations were studied with path analysis. Women reported poorer oral health-related quality of life, higher pain levels, and had more severe TMD than men, but the gender difference was statistically significant only in pain and TMD. In contrast to the hypothetical model, among women the occlusal characteristics were not directly associated with oral health-related quality of life or facial pain. Among men, the occlusal characteristics were directly associated with oral health-related quality of life. In conclusion, patients with severe malocclusion who also have TMD and facial pain more often have impaired oral health-related quality of life. The associations of the occlusal

characteristics with oral health-related quality of life differ between genders. Therefore, these associations should be studied separately among genders.

Mendoza-Mendoza, A., Solano-Reina, E., Iglesias-Linares, A., GarciaGodoy, F. and Abalos, C. (2012)[52] This retrospective case-series study aimed to examine the long-term outcomes of autogenously transplanted premolars.

Twelve patients in whom donor premolars were used to replace maxillary central incisors lost by trauma were clinically and radiologically monitored. Standardized clinical and radiographic records were systematically obtained during the follow-up period of 14 years, to determine the influence of specific clinical criteria on the overall success rate of transplantation.

The success rate of premolar autotransplantation in the maxillary central incisor area was 80% after 14 years follow-up. The highest success rate occurred in those teeth transplanted with two-thirds of full root development. Complete pulp obliteration was positively related to autotransplant viability, followed by root formation in the bony crypt.

Autotransplantation of donor teeth, at the stage of ½ to ¾ of their expected root length, can provide a successful treatment solution for over 14 years

Pawel Plakwicz (2013)[55] The aim of this prospective clinical trial was to examine te predictability of the protocol for premolar transplantion

when applied by inexperienced surgeon the samples comprised 23 consecutively transplanted developin premolar in 19 patients the survival rate was 100% antd the success rate was 91.3% the protocol for autotoothtransplantation of deveoping premolars in growing patients was successfully adopted.

Delphine Denys*, Maryam Shahbazian*, Reinhilde Jacobs*, Annouschka Laenen, Jan Wyatt*, Frans Vinckier* and Guy Willems (2013)[69]** The aim of the present study was to perform a retrospective study of autotransplanted teeth with a variable but individually maximized follow-up period in order to provide information on the long-term clinical outcome. Autotransplantation can be a valid alternative method in young adolescents for replacing missing teeth because of agenesis or trauma. The optimal time to transplant is when the root has reached two-thirds to three-quarters of the final root length

Huth et al (2013)[74]: In this study, 57 teeth were transplanted on 45 patients. of those, 37 teeth were canines, 10 were molars, 7 premolars, and 3 incisors. the aim was to determine the success rate of the procedures. The overall success was 74%, along with high patient satisfaction. the success criteria were probing depth <or = 3.5mm, mobility grade < or = 2, periotest < or = 30 as well as complete alveolar healing. the influencing parameters included oral hygiene, smoking, periodontal screening index, occlusal/proximal contacts, horizontal position, dental age, pulp obliteration

and degree of displacement. the technique used in this was the one described by Anderson et al, and all auto transplantations were performed by one experienced maxillofacial surgeon. endodontic treatment was performed if periapical periodontitis or root resorption was detected. For the post-operative radiographic examination, digital radiographs were obtained to examine periapical status and bone healing and root resorption. the mean age of the patients at the time of surgery was 17. the survival rate was 96% after a mean follow up of 1.6 years. the clinical failure criteria were a periodontal probing depth > 3.5mm, a tooth mobility grade of 3, or a periotest value >30. the radiographic failure criterion was incomplete alveolar bone presenting a rarefied area larger than the periodontal ligament space surrounding the transplanted tooth. The success rate for canines was 73%, for molars 70%, for premolars 71% , and for incisors 100% Oral hygiene showed a statistically significant influence on the success rate, as did smoking, the presence of proximal contacts and pulp obliteration.

Abu-Hussein M.; Sarafianou A ., Abdulgani A (2013)[64]

Intentional reimplantation is a procedure in which tooth extraction is performed followed by reinsertion of the extracted tooth into its own socket after performing the desired procedure. In this article, intentional reimplantation is described and discussed as a treatment approach for aperiapical lesion that is in maxillary second molar. After 15 years, the patient was asymptomatic, the tooth was still functional and a recall intraoral

periapical radiograph showed an intact periodontal ligament space and lamina dura with no evidence of gross root resorption or ankylosis. Keywords: Intentional replantation, calcified canals, mineral trioxide aggregate

M. Salmi. (2013)[78] Additive manufacturing is a material adding fabrication process, which suits for manufacturing objects with complex geometric shapes for either one piece or small series production. The parts are produced automatically according to a digital 3D model. By digitalizing the medical processes of additive manufacturing can be easily and rapidly performed. Therefore, it is a suitable manufacturing method in both surgery and dentistry.

Nimcenko, T., Omerca, G(2013)[6] Rapidly evolving implantation and alveolar ridge reconstruction techniques created a new area in modern dentistry where tooth loss is no longer a problem. Endless variations of implant's length, diameter, surface, and design along with autogenous, alogenous, aloplastic, or xenogenous bone substitutes made it possible to recreate physiological occlusion, esthetic and masticatory function. However, none of nowadays technologies in implant dentistry have the potential to adapt to a growth and development changes of a child's jaw. Therefore, patient's young age is a restriction for implantation and a particular challenge for a dentist willing to restore missing tooth. Thus, tooth auto-transplantation can be a good choice for treatment. The objective of this review is to underline the

biologic principles required for successful auto-transplantation of teeth. Limits, indications, technique, and prognosis will be analyzed.

Cross, D., El-Angbawi, A., McLaughlin, P., Keightley, A., Brocklebank, L., Whitters, J., et al. (2013)[11] Transplantation of teeth has been done for hundreds of years. In the late 18th and early 19th century transplants of teeth between individuals were relatively common at specialist dental practices in London. Surprisingly tooth allotransplants have been found to last 6 years on average. In Scandinavia during the 1950 and 1960's autotransplantation of teeth began to be carried out under increasingly controlled conditions. These have proved to be very successful in long term studies with autotransplants surviving up to 45 years post-surgery. Recent developments in cone beam CT and rapid 3D prototyping have enabled the fabrication of accurate surgical templates which can be used to prepare the recipient site immediately prior to transplantation. This has resulted in a drastically reduced extra-oral time for the transplant teeth which can be expected to improve success rates further. Autotransplants provide significant advantages compared to single tooth implants and should be considered the treatment of choice in the growing child.

Ashkenazi, M. and Levin, L. (2014)[57] The aim of this study was to suggest a way to fabricate surgical templates to assist the surgeon in preparing the recipient socket when performing premolar autotransplantation

The advantage of the presented metal tooth-like surgical templates described in this study is that a set of stents has been produced by replicating different common shape adolescent premolars that reflect the biological variation in size and shape of these teeth.

Moin, D. A., Hassan, B., Mercelis, P. & Wismeijer, D. (2014)[8] The aim of this in vitro pilot investigation is to assess the accuracy of the preemptive individually fabricated root analogue implant (RAI) based on three-dimensional (3D) root surface models obtained from a cone beam computed tomography (CBCT) scan, computer-aided designing (CAD), and computer-aided manufacturing (CAM) technology and to measure the discrepancy in congruence with the alveolar socket subsequent to placement of the RAI. The preemptive CAD/CAM-based RAI technique might offer promising features for immediate implant placement. However, due to the lack of prospective clinical data, further research is needed to fine-tune and evaluate this technique.

Ashkenazi, M. & Levin, L(2014)[16] The aim of this study was to suggest a way to fabricate surgical templates to assist the surgeon in preparing the recipient socket when performing premolar autotransplantation.

Premolars used previously for extractions of periodontal ligament (PDL) fibroblasts were used in this study as archetype of models for tooth transplantation. Eighty-four mandibular and maxillary first and second extracted premolars were reviewed. All teeth were extracted for orthodontic

reasons. From these teeth, eight teeth were selected to serve as archetype of models in which all the other teeth were at equal size or smaller in maximum 2 mm in M-D or B-L dimension. These teeth were sent to dental technician to perform identical archetype stainless steel templates. During autotransplantation immediately following donor tooth extraction, the appropriate template is chosen out of the toothlike stainless steel surgical templates and the donor tooth is then immediately replaced in its socket. This enables the surgeon to prepare the recipient site without manipulating the donor tooth and thus preventing damage to the PDL cells of the donor tooth. Only after the recipient site had been prepared to the appropriate size and shape according to the template, the donor tooth is removed from its socket, immediately placed at the recipient site and splinted as recommended.

The advantage of the presented metal tooth-like surgical templates described in this study is that a set of stents has been produced by replicating different common shape adolescent premolars that reflect the biological variation in size and shape of these teeth.

Abu-Hussein Muhamad1*, Watted Nezar2, and Abdulgani Azzaldeen(2014)[67] Tooth avulsion in the permanent dentition constitutes a dental emergency. Replantation of the avulsed tooth restores aesthetics and occlusal function shortly after the injury. This article describes the management of a 12-year old male with four avulsed anterior maxillary permanent teeth. The avulsed teeth were replanted and root canal treatment

carried out after a short fixation. The result obtained was very satisfactory and the teeth remain in good functional status one year after replantation. Early treatment and regular attendance to clinic following replantation is an important factor for good result.

A. Hazeveld, J.J. Huddleston Slater, Y. Ren (2014)[79] Rapid prototyping is a fast-developing technique that might play a significant role in the eventual replacement of plaster dental models. The aim of this study was to investigate the accuracy and reproducibility of physical dental models reconstructed from digital data by several rapid prototyping techniques..

Dental models reconstructed by the tested rapid prototyping techniques are considered clinically acceptable in terms of accuracy and reproducibility and might be appropriate for selected applications in orthodontics.

Chung WC, Tu YK, Lin YH, Lu HK(2014)[28] In this review, we assessed clinical outcomes of autotransplanted teeth with complete root formation and the effects of various influencing factors.

Tooth autotransplantation with complete root formation is a favourable treatment with rare FR, RR and AR. However, SAs, endodontic and splinting modalities and tooth morphology seemed to influence the outcomes.

Kianoosh Torabi a, Ehsan Farjood a, Shahram Hamedani (2015)[70] The early computer-aided design/computer-aided manufacturing (CAD/CAM) systems were relied exclusively on subtractive methods. In recent years,

additive methods by employing rapid prototyping (RP) have progressed rapidly in various fields of dentistry as they have the potential to overcome known drawbacks of subtractive techniques such as fit problems. This paper aimed to offer a comprehensive literature review of various RP methods, particularly in dentistry, that are expected to bring many improvements to the field. A search was made through MEDLINE database and Google scholar search engine. procedures employed in this method and confirmed that RP technique have been substantially feasible in dentistry. With advancement in various RP systems, it is possible to benefit from this technique in different dental practices, particularly in implementing dental prostheses for different applications.

Konstantinia Almpani1 & Spyridon N. Papageorgiou2,3,4 & Moschos A. Papadopoulos(2015)[10] The aim of this investigation was to assess the currently available evidence concerning the complications and risk factors influencing the outcome of autotransplantation of teeth in humans. Due to the small number of the contributing studies, their methodological limitations, and the heterogeneous results reported, no firm conclusions can be drawn. Clinical relevance Root development of the donor teeth has beenestablishedasonethemostimportantfactorrelatedtothe success of tooth autotransplantation.

Machado LA, do Nascimento RR, Ferreira DM, Mattos CT, Vilella OV(2016)[29] The aim of this study was to systematically review the prognosis

of autotransplanted teeth followed up for a period of 6 years or more. A literature search was conducted in five databases and the eligibility criteria were established. The results of this study showed the survival rate to be excellent, considering the observation period. The rates of ankylosis and root resorption, despite their low values, influence the prognosis of transplanted teeth

JP Verweij1 (MD, Resident Maxillofacial Surgery); D Anssari Moin2 (DMD, Dentist); G Mensink1,3 (MD, DMD, PhD, Maxillofacial Surgeon); P Nijkamp1 (DMD, Orthodontist) D Wismeijer2 (DMD, PhD,); JPR van Merkesteyn1 (2016)[1] This study investigates the use of a computer-aided designed (CAD) 3D-printed titanium replica of the donor tooth which can be used as a surgical guide during the autotransplantation procedure The surgical guide protects the donor tooth from iatrogenic damage by reducing the extra-alveolar time and minimizing the number of fitting attempts during the preparation of a neo-alveolus. This enables a quick and easy autotransplantation procedure.Successfully transplanted premolars can function as normal teeth with a high long term survival rate. The procedure is nevertheless still accompanied by the risk of complications, such as root canal obliteration, root resorption, ankylosis, endodontic pathology, and periodontitisTooth survival and success after autotransplantation mainly depend on the prevention of damage to the periodontal ligament and nerve/apex of the donor tooth.

Karolina Mikkelä Stange, Rune Lindsten, and Krister Bjerklin* (2016)[3] To investigate the long-term outcome of treatment of missing maxillary incisor teeth by transplantation of premolars, with special reference to aesthetics and patient satisfaction Twenty subjects who had undergone transplantation of premolars to the maxillary incisor area were recalled for follow-up varying between 12 and 22 years post-surgery. Twelve subjects presented for examination, including radiography and three subjects participated only by answering questions. Three reference groups—general practitioners, orthodontists, and lay people—evaluated the aesthetic results from photographs. Patient satisfaction was evaluated by interviews Autotransplantation of premolars is an appropriate method for treatment of missing maxillary anterior teeth. Subjects with a transplanted tooth to the maxillary anterior region perceive their oral health as good long term.

Christensen LR. (2017)[72] Digital workflows are now increasingly possible in orthodontic practice. Workflows designed to improve the customization of orthodontic appliances are now available through laboratories and orthodontic manufacturing facilities in many parts of the world. These now have the potential to improve certain aspects of patient care**.**The rising popularity in intraoral scanning has opened up new avenues for planning, designing, and executing orthodontic treatment for our patients. This paper is by no means an exhaustive review of all the available options on the market but simply aims to give the reader ideas of some of the new workflows

in the area of digital orthodontics.ntraoral three-dimensional (3D) data can be collected in many ways. Impressions or cast of patients can be scanned with desktop scanners and digital study models created for diagnostic purposes or to produce orthodontic appliances. Although this path is perfectly possible, one of the reasons for a digital workflow would be to avoid impression taking and model fabrication; this option is more suitable for eliminating larger quantities of already produced study models. The storage of models is often an issue for larger orthodontic practices as regulations surrounding medico-legal records often prohibit clinicians from discarding these. Several colleagues have been able to free up so much space from storage that they have been able to utilize the space for a new treatment room or something equally productive.The introduction of intraoral scanning has helped us to produce new practice workflows that have enabled us to produce more complex appliances with high precision. This has most certainly benefitted the patients and in many situations has eliminated appointments such as separation placement and repeated appointments for retainer impressions. Over the last 2½ years, we came across only one patient who preferred the alginate impressions.

The time-saving aspects of not having to courier impressions or other records overseas for the preferred laboratory means that we can now work with our preferred partners much more efficiently and at a little less cost.

T. Tsurumachi1 & T. Kuno (2017)[9] This case report describes the autotransplantation of a maxillary premolar after the extraction of an ankylosed incisor in a 13-year-old boy. In this case, the first premolar had one buccal and one palatal roots. Thus, extraoral removal of the buccal root was performed to achieve adaptation to the narrower recipient site. Root removal was a less invasive and quicker than modification of the recipient bone site This case demonstrates that autotransplantation of a maxillary premolar may provide the potential to replace an ankylosed anterior tooth with a natural tooth instead of a prosthesis or osseointegrated implant even following the removal of the buccal root. At a 7-year follow-up, the transplanted first premolar was clinically healthy and continued to satisfy aesthetic and functional demands

Concepts nazeer(2017)[61] The main purpose of this specific technique is to substitute a tooth, that has been lost or that has indication for extraction, because of a bad prognosis, by another tooth that presents more advantages for being in the receptor area, and/or that has no function in its primary location. It can be considered, in a wider concept of tooth autotransplantation for some authors such as Tsukiboshi, distinct situations: First, when a tooth is extracted from a location and reimplanted in a different one, which is named tooth transplantation; Second, when a tooth is repositioned in its own alveolus, as in verticalization of 3rd molars or surgical extrusion of a tooth; Third, and finally, when an extracted or avulsed tooth is treated and reimplanted in its

own location sometimes as an alternative to periapical surgery This is a more global concept including intraalveolar transplantation and intentional reimplantation, because all are characterized by a similar healing process.

Autotransplantation of teeth are an alternative as any other and should be considered when planning a treatment. This technique can give some advantages, such as a possibility for a fixed bridge (where before it would only be possible to place a dental implant or removable prothodontics), the reposition of teeth without orthodontics, the use in helping to solve agenesis problems and the surgical extrusion of fractured teeth (to allow dentistry/fixed crowns).

This technique usually requires one surgery. Besides all this advantages, one of the biggest is the fact that the patient regains a proprioceptive feeling in the transplanted tooth, with normal periodontal healing, allowing a natural feel during chewing[4. But the main advantage is the use in children and adolescents, because of its continuous induction on the alveolar bone, and therefore allowing for the normal physiological alveolar growth.

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Materials and Methods

MATERIALS AND METHODS

This study This study was conducted at the department of Oral and maxillofacial surgery, Ragas dental college and hospital. Five partially edentulous human adult mandible not identified by age, gender or ethnic group was obtained from the anatomy department. Pediatric mandibles and Decomposed mandible with little of its internal structures intact, and edentulous mandible were excluded. A declaration was obtained from the anatomy department to use this human remains material for research purposes. 3 single rooted and 2 multirooted tooth. The teeth were sound with no amalgam fillings or external root resorption and showed no peri-apical lesions. This study was performed in accordance with institutional guidelines, and ethics was followed. The study protocol was reviewed and approved by the institutional ethical review board.

- 5 teeth in a dry mandibles were used in this study
- Medical CT Image data to 5 dry edentulous mandible obtained in DICOM format
- Using Mimics software 3dimensional reconstruction of donor tooth done and saved as STL format.(MIMICS - MATERALISE,BELGIUM)
- Replica of the donor tooth is printed with polymethyl metha acrylate with help of 3D injection moulding machine ,which act as a surgical guide

- Surgical guide is used to prepare the new alveolor socket in the recipient site.
- Round and flame shaped surgical drill bits

The mandible were scanned with a CT machine (Accuitomo 170 CT system AccuiTomo 170, 90 kVp, 5 mA, 30.8 s, 4 9 4 cm Field of View [FoV]; Morita Inc., Kyoto, Japan). The isotropic voxel size and slice interval were 0.08 mm. The scan volumes were exported in DICOM 3 format and imported into image analysis software mimics, materialize - Belgium. The datasets were used to create 3D surface models of the tooth. The exact procedure for segmenting the tooth was the following: A region of interest limited to the tooth and surrounding periodontium was first selected. Subsequently, a threshold value based on the histogram analysis, the local grey level value and image gradient were selected to separate the root and crown from the surrounding bone. The resulting images were processed using interactive processing tools to remove resulting artefacts. . The resulting surface was exported in STL format without reduction of the number of triangles.

Simulation:

For simulation of surgery on the dry mandible the selected donor teeth were segmented from the DICOM images. The 3D image of the tooth was manipulated to place in the recipient site to assess the feasibility based on the available bone in all three dimension namely adequate height, mesio distal and bucco lingual width. If there is any interference with the adjacent tooth and the

requirement of any orthodontic treatment was also evaluated pre operatively. When all the preoperative evaluation proves the feasibility of the auto tooth transplantation, the STL file is sent to prepare the tooth analogue template by the rapid prototyping technology.

CAD/CAM process:

A high-end inject technology was used to fabricate the tooth analogue from the STL file. The tooth analogue was produced in a Poly methyl methacylate.

Surgical feasibility:

The RP tooth analogue was used as a surgical guide for the preparation of recipient site. This guide was used in socket preparation of the dry mandible to have reproducible position. After visualization of the RP tooth analogue, the neo-alveolus at the recipient site was prepared with the help of the conventional drills. The 3D-printed replica (surgical guide) was fitted to make sure the donor tooth would fit exactly in the artificial socket. Second, the donor tooth was extracted with forceps, and care was taken not to damage the cementum, periodontal ligament, or apex of the tooth. The surgical guide and donor tooth were compared to evaluate possible differences between the 3D-printed replica and the original tooth. The donor tooth was placed into the new alveolus in slight infraocclusion to prevent occlusal forces postoperatively.

DATA COLLECTION:

The following data were collected: the height and mesio distal width of the tooth, root shape and its feasibility as donor tooth without any complex

root curvature. The recipient site was also evaluated. Intraoperative data were recorded, including the fitting attempts with the surgical guide, the extra-alveolar time of the donor tooth, and the number of fitting attempts needed to place the donor tooth in the newly prepared alveolus at the recipient site.

Figures

FIG 1 : SINGLE ROOTED AUTO TOOTH TRANSPLANTATION

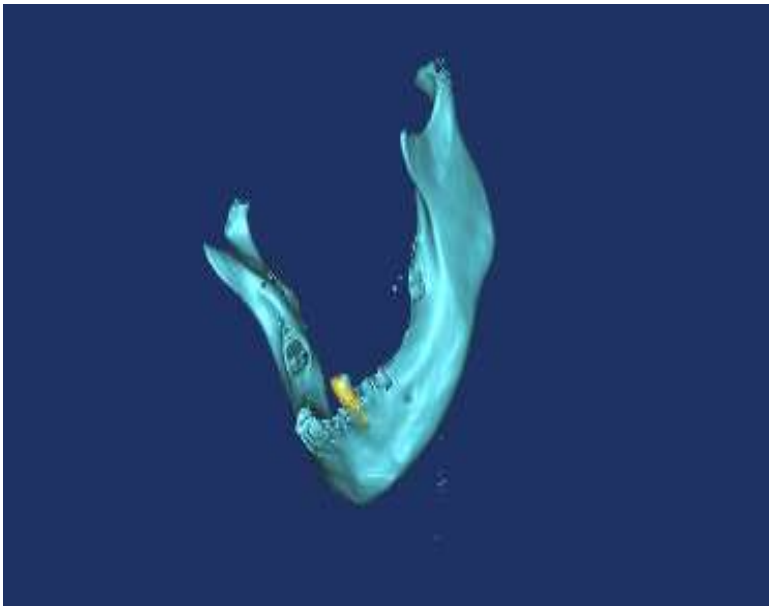

FIG 2 PREEVALUATION TO CONSIDER THE ANATOMIC POSITION THROUGH CROSS SECTION

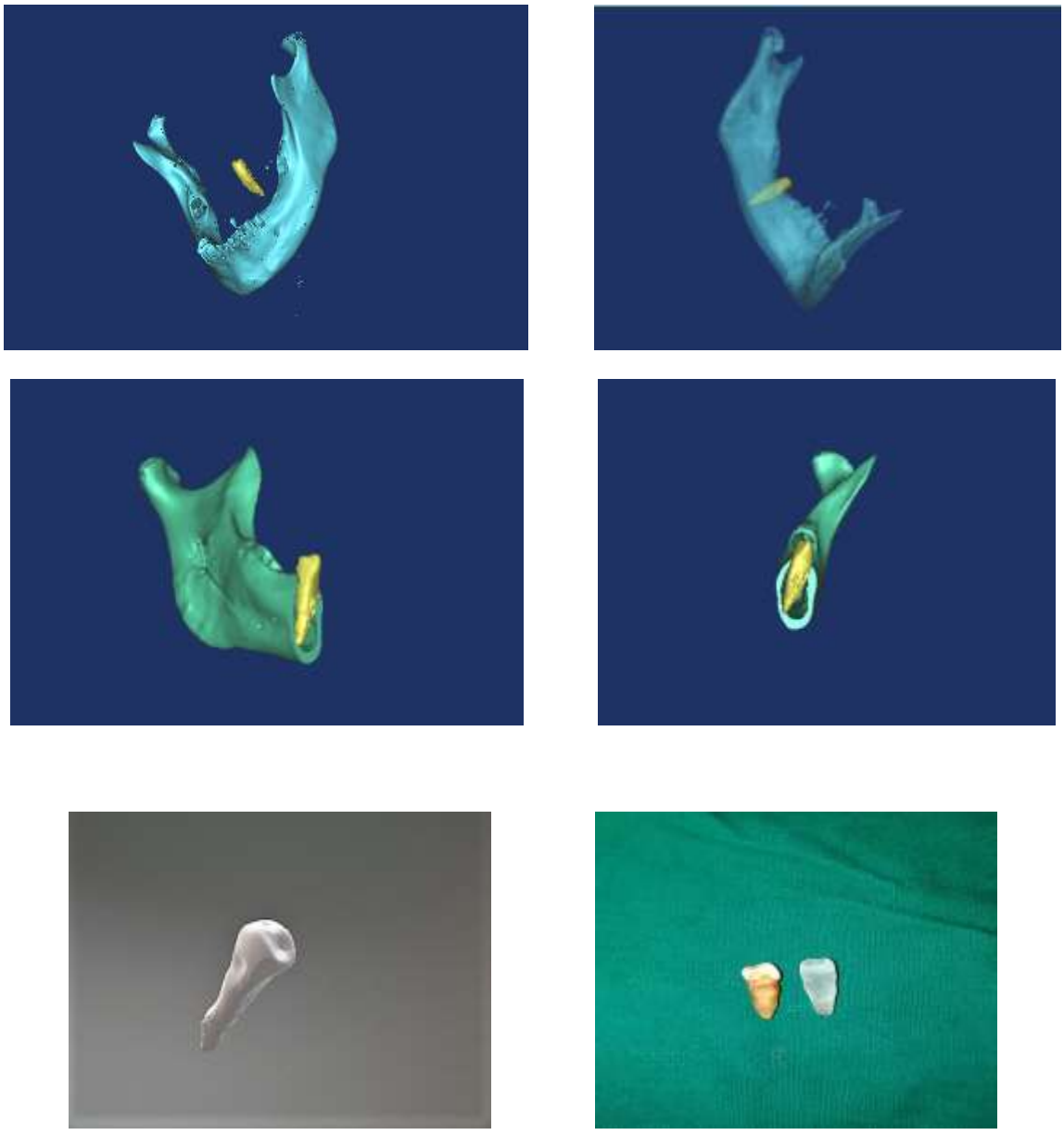

FIG 3: DRY MANDIBLE AND 3D RECONSTRUCTED MANDIBLE

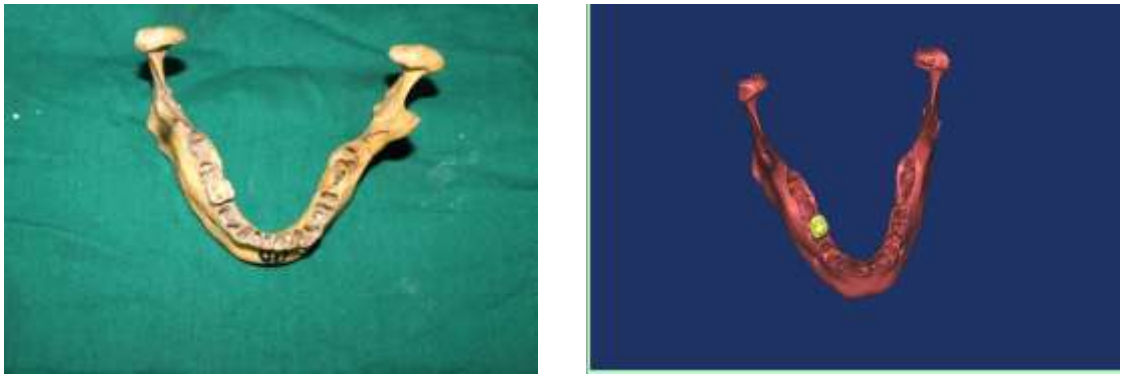

FIG 4 : TOOTH TO BE 3D RECONSTRUCTED IS SEPERATED FROM THE MANDILBLE

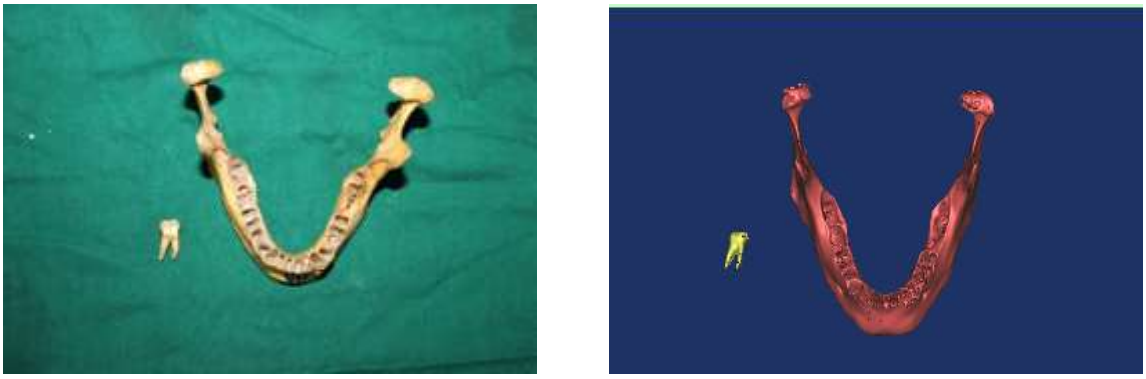

FIG 5 : CONVERSION OF TOOTH IN TO 3D MODEL AND PRINTED

FIG 6 : MEASURING MESIODISTAL AND BUCCOLINGUAL WIDTH OF DONOR SITE AND TRANSFERRING TO RECEPIENT SITE

FIG 7: EVALUATING THE RECEPIENT SITE BEFORE PREPARING THE SOCKET USING 3D CONSTRUCTED MANDIBLE BY PLACING THE TOOTH

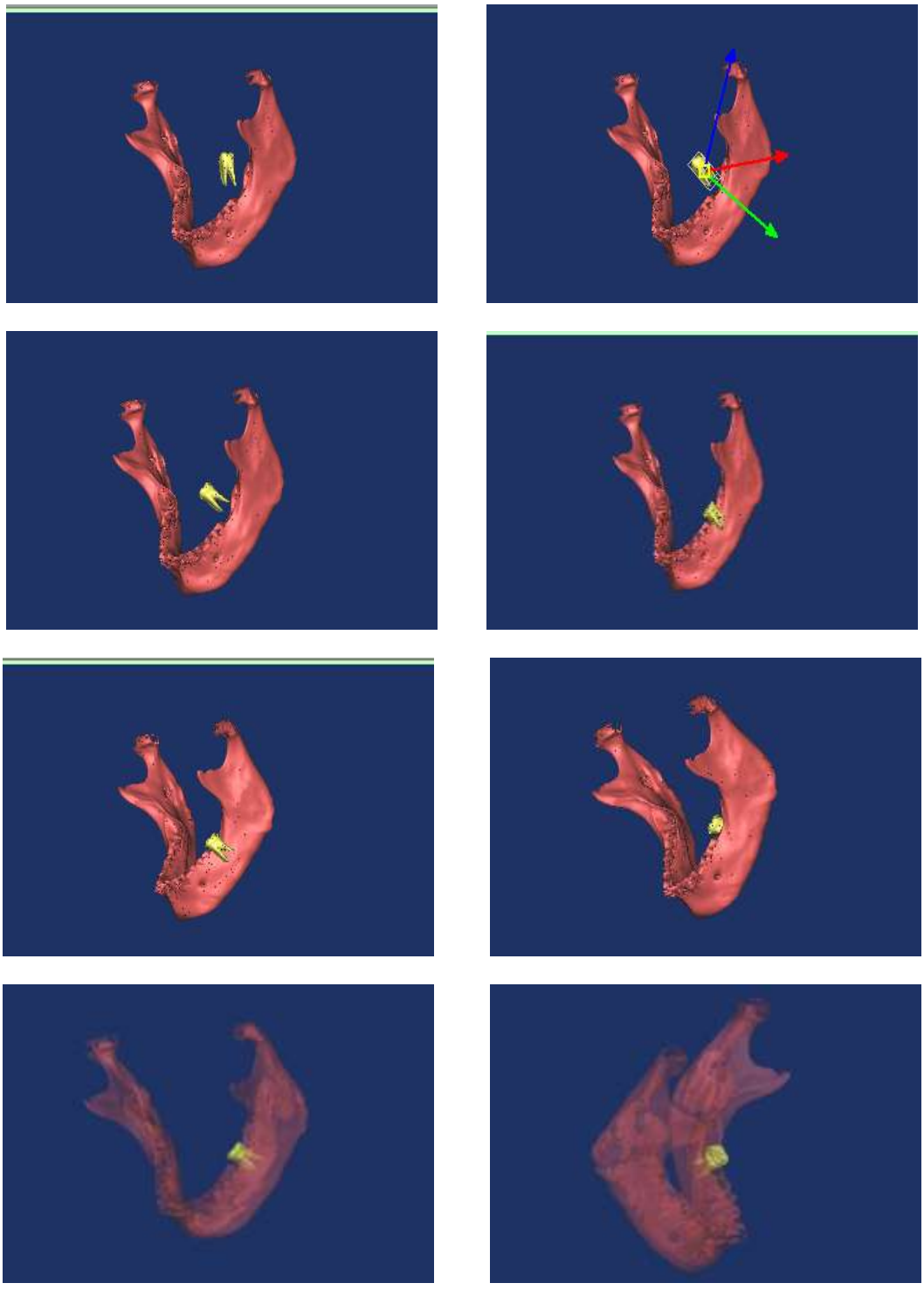

FIG 8 : PREPARING THE RECEPIENT SITE IN DRY MANDIBLE AFTER 3D EVALUATION OF POSTIONING OF TOOTH

FIG 9 : SURGICAL DRILL BITS---ROUND AND FLAME SHAPED USED

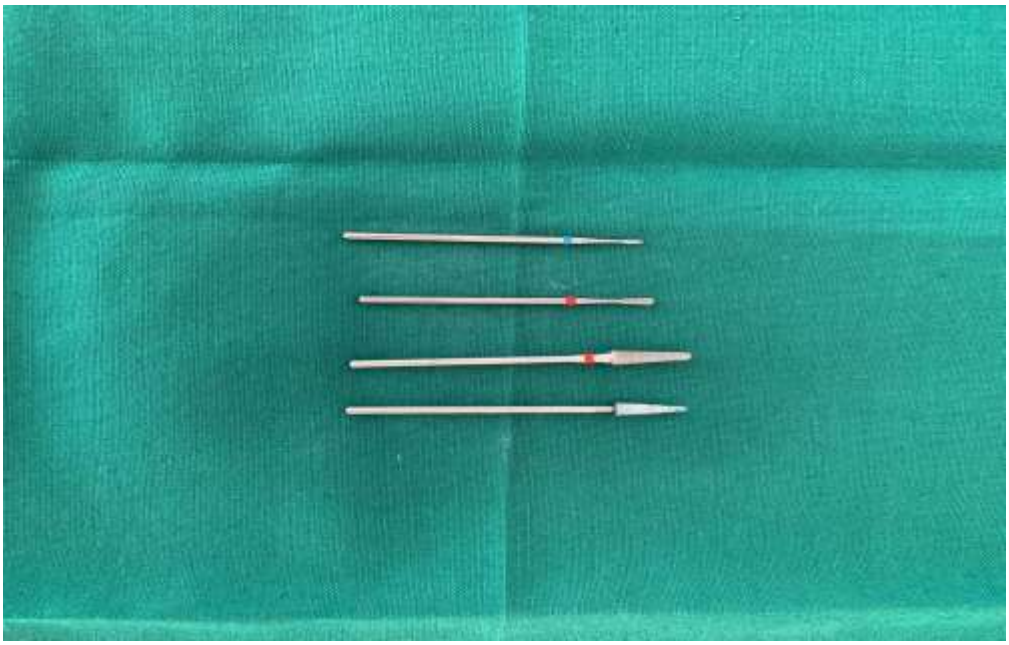

FIG 10 : PLACING THE 3D PRINTED TOOTH IN THE RECEPIENT STE AND CREATING THE SOCKET

FIG 11 : TRANSFERRING THE EXTRACTED TOOTH IN TO THE NEWLY PREPARED ALVEOLUS

MESIODISTAL MEASUREMENTS

TOOTH	NORMAL TOOTH MEASUREMENTS	PRINTED TOOTH MEASUREMENTS
34	9..5 MM	9.5 MM
44	10.2 MM	10.2 MM
38	10.5 MM	10.3 MM
37	10.2 MM	10 MM
24	9 MM	8.8 MM

BUCCOLINGUAL MEASUREMENTS

TOOTH	NORMAL TOOTH MEASUREMENTS	PRINTED TOOTH MEASUREMENTS
34	14.5 MM	14. MM
44	14.2 MM	14.2 MM
38	13.5 MM	13.3 MM
37	15.2 MM	15 MM
24	14.5 MM	14.3 MM

HEIGHT OF THE TOOTH

TOOTH	NORMAL TOOTH MEASUREMENTS	PRINTED TOOTH MEASUREMENTS
34	7.5 MM	7.5 MM
44	8.2 MM	8.2 MM
38	7.5 MM	7.3 MM
37	7.2 MM	7.0 MM
24	6.5 MM	6.3 MM

HEIGHT OF THE TOOTH AT THE LEVEL OF CEJ

TOOTH	NORMAL TOOTH MEASUREMENTS	PRINTED TOOTH MEASUREMENTS
34	9 MM	9 MM
44	10 MM	10 MM
38	9.5 MM	9.3 MM
37	10.2 MM	10 MM
24	8 MM	7.8 MM

FIG 12 Tooth Measurements

Results

RESULTS

This This observational study analyzed the use of a 3D-printed replica of the donor tooth to facilitate the autotransplantation procedure. Visual comparison of the donor tooth and its replica showed no remarkable differences. The accuracy of the 3D model of pre-molar obtained by segmentation was compared with the 3D prototype model. The STL tooth model was used as a guide for a prior reshaping and proper matching between root surface of the donor tooth and recipient site.

Artificial tooth sockets was prepared at the site of the mandibular first premolar and molar region with the help of the 3D print of the donor teeth. The replica was fitted to make sure the donor tooth would fit exactly in the artificial tooth socket. The donor tooth was extracted with an elevator and forceps, while care was taken not to damage the cementum and apex of the tooth. Comparison of the donor tooth copy and the original tooth again showed no differences with regard to the shape of the root and crown in both cases. The mandibular third molar was placed at the site of the first molar and the right mandibular third molar was placed at the site of the second molar of the 3rd quadrant. The donor teeth were again placed in a slight infraocclusion. For both the left and right third molar, an immediate good fit at the recipient site was achieved with an extra-alveolar time of respectively one minute and nine seconds(1.09sec), and 53 seconds(53 sec)

Discussion

DISCUSSION

The distinguished surgeon John Hunter referred to the practice of wrenching a tooth from the jaw of an "indigent and helpless" for a "fine lady" being done for the price of a meal . He also conducted experiments himself in transplantation and reported an incidence of a successful tooth allotransplant in a gentleman in London, in 1772. Stack, in 1883, commented that transplants, replants and repositioning should be done for the poor, who could not afford the artificial dentures[61]

The autoimplantation of teeth is a recognised treatment option where teeth are absent due to anodontia, trauma or pathological loss. It involves elective removal of a donor tooth and its insertion into a surgically prepared recipient socket. It is a cost-effective biological alternative to either restorative rehabilitation involving bridge or implant (and bone graft) solutions, or orthodontic space closure. The advantages of autotransplantation are early tooth replacement in a growing individual and functional restoration of the edentulous site[61]

This is specifically the case for adults who often reject the idea of a long-term orthodontic appliance therapy, in order to align an ectopic tooth, yet would benefit greatly from positioning this tooth in the dental arch . It is also indicated in cases where the ectopic tooth's position is such that it is impossible or too risky to move into a proper position in the arch, by using

solely orthodontic means. In these cases, autoimplantation could constitute a safer, alternative treatment option[55].

Autoimplantation of maxillary premolars to replace missing mandibular premolars is the most common optional treatment done. This option is particularly useful when orthodontic extraction therapy of the maxillary premolars is indicated[23]. The first molars are the most common permanent tooth lost due to caries and periodontal diseases. The third molars may be considered for the replacement of this tooth[64]. Tooth implantation is preferred for the replacement of teeth in cleft lip and palate patients as it induces alveolar growth potential especially during adolescence. This is a viable alternative to other treatments because of predictable clinical outcomes[66] The recipient area receiving the transplant should be healthy with adequate alveolar bone support. Should be free of any infection or chronic inflammation. Donor tooth should be extracted atraumatically, hence abnormal root morphology is a contraindication for transplantation[26].

A tooth with complete root formation requires Root canal treatment after transplantation. Root canal treatment is usually done after transplantation and may be completed before removal of the splint[61]. The most predictable clinical outcomes is achieved when teeth whose roots are only one half and two third of root completion are transplanted. These teeth remain vital ensuring root end closure physiologically with no need for endodontic treatment. Transplanted teeth with incomplete root formation have a 96% rate

of pulpal healing, compared with 15% for transplanted teeth with complete root formation[61]. The type of healing of transplanted tooth is dependent on the surface area of the extrcted tooth root . When the damaged PDL surface is minimal, the healing can be achieved by cemental healing. However when the damaged PDL surface is large, some of the root surface will be resorbed followed by apposition of bone rather than dentine, thus root resorption will ensure[63]

The tooth to be transplanted should be out of its socket a minimal amount of time to avoid desiccation. The longer the tooth is left outside the socket, the poorer the prognosis[26]. Excessive time or rigid splinting of the transplanted tooth will adversely affect its healing outcome. The splint should not force the tooth against the bony walls of the alveolus because it may damage the periodontium**.**The most critical procedure in surgery is tight closure of the gingival flap around the donor tooth. This optimizes reattachment and, importantly, may block bacterial invasion into the blood clot between the tooth and socket. In order to achieve this close adaptation around the donor tooth, trimming of flap is needed in some cases, and suturing of flap before the donor is positioned into the socket is recommended in every case.splinting by means of sutures is then performed. If the autoimplant is not stable after suture splinting or if much more occlusal adjustment is necessary, splinting is changed to one with wire and adhesive resin. If the transplant is not stable but no occlusal adjustment is needed, splinting with wire and resin

can be delayed for 2 or 3 days after suture splinting because the former is time consuming and bleeding during the surgical procedure makes optimal results difficult[67]

The causes of failure of the autoimplanted tooth root with resorption could be inflammatory resorption, ankylosis, marginal periodontitis, apical periodontitis, caries, and trauma. The potential complications of this surgical technique include ankylosis, pulp necrosis and inflammatory or replacement root resorption. The long-term rate of ankylosis was 4– 18% (with an effect size of 4.8%) and root resorption was 3–10%. As with survival rates, the worst complications were seen in studies with mature root transplantations[29]. Inflammatory resorption may become evident after 3 or 4 weeks, while replacement resorption may not become evident until 3 or 4 months after transplantation[66]. An atraumatic surgical technique preserves bone and periodontal support. Minimal handling of the transplant is required to protect the Hertwig'sroot sheath and pulpal tissue; otherwise root growth may be compromised,leading to ankylosis or root resorption and attachment loss[29]

Preservation of the periodontium of the grafted tooth is key to a successful clinical outcome. When the periodontal fibers are vital, natural reorganization of the periodontal fibers occurs. Periodontal healing is usuallycompleted after 7-8 weeks and can be diagnosed radiographically as a continuous space around the root with absence of root resorption and presence of a lamina dura. The final position of the donor tooth within the recipient

socket influences periodontal healing. The donor tooth should be placed so that 1 to 2 mm of the width of the periodontal ligament stays above the bone crest to achieve an ideal biologic width.Apical migration of epithelium may occur and result in vertical bone resorption due to deep placement or long connective tissue attachment due to too shallow placement[36]

Tooth implantation has variable success rates, as reported in a recently published meta-analysis of periodontal conditons of implanted teeth with a minimum follow-up period of 6 years. This demonstrated longterm survival rates of 75–91% with an effect size of 81%, despite the inclusion of studies with mature tooth implantations. This is consistent with the findings of previous individual studies which indicate that clinical success rates (notably 'success' includes clinical criteria in addition to tooth survival) are affected by: patient age and the stage of root development of the donor tooth; the surgical time involved in the transplant process, and iatrogenic trauma to Hertwig's root sheath[45].

The most appropriate donor teeth in children are upper and lower second premolars because of their relatively favourable root number, morphology and the timing of their root development. These factors mean that premolar transplants tend to have higher success rates than other donor teeth. For example, in a study of 215 consecutive patients the long-term success rate for premolars transplanted to upper incisor sites was 100%, compared to the total sample mean of 81%[39]. Therefore, second premolar teeth are the

optimum candidates for the replacement of absent maxillary central incisors in terms of both their high success rate and favourable secondary outcomes. For example, a favourable gingival response was observed in the study undertaken

Various attempts have been made to reduce tooth implantations surgical morbidity, including fabrication of metal templates apparently representing typical premolar sizes and morphologies These could be used to pre-prepare the recipient site and the trauma to the periodontal tissues that occured when the tooth is repeatedly tried into the recipient socket can be prevented. However, the template would not be an exact replica of any individual patient's donor tooth this issue is addressed by individually customising the template. CT scan radiography data is used to print a rapid prototype version of the donor tooth in either 'resin' or starch, i.e. a donor analogue[27]

A follow-on study by South Korean team analysed the results of 182 transplanted teeth, where 90% were mature third molar teeth[25]The mean extra-oral time for the donor tooth was only 7.2 minutes where the donor teeth did not undergo extra-oral endodontic treatment. Significantly, the rate of complete early healing was higher (88%) in cases with good primary stability compared to cases where poor primary stability was observed (73%).

This suggests that the use of a customised analogue may assist the surgeon to achieve favourable primary stability of the transplanted tooth, fabricating the CARP **(computed aided rapid prototyping)** models using CT images. The

CARP model could reduce the extra-oral time and also minimise the damage of the periodontal ligament cells during fitting the donor tooth into the newly prepared socket to achieve a good fit[62]

This CARP models used at their studies was reported to have an average of absolute error value, 0.291 mm with the real teeth. As CBCT technology develops, reported the successful autotransplantation case of impacted immature permanent teeth had a high success rate as they made use of the CBCT images and CARP model[62].

This CBCT can reduce the costs and radiation irradiation volume in comparison with spiral CT. Additionally, they scanned the SLA model on real teeth, and then reported the errors of surface range within 0.25 mm. Rapid prototyping has been introduced in health care application lately when compared to its long-standing use in the manufacturing industries. In the last decades, rapid prototyping has been used in various medical applications including individual patient care; surgical planning, implant and tissue designing, research and as an educational and training tool of study that was undertaken an in vitro study compared the dimensions of stereolithographically printed plastic teeth with that of the corresponding real teeth. They found that 79% of the surface points analysed were within 0.25 mm accuracy, indicating that the printed teeth were sufficiently similar to the real ones for clinical use. Aside from possible shrinkage or distortion of the

printed plastic, the errors may have also been due to the relatively low resolution of the CBCT scans used[17]

More recently,the another study utilised CBCT derived data to produce a 3D printed analogue of a molar tooth transplant. They described this in an adult patient where the surgeon used the analogue in an attempt to make the recipient site the optimal size prior to insertion of the real tooth. However, none of these reports of 3D printed analogues have described the more typical scenario in children of transplantation of an immature premolar tooth into an edentulous alveolarsite. Honda.m(2010) reports a case where a CBCT-derived 3D printed analogue was made of an immature premolar tooth destined for a maxillary incisor site. The relevant preparatory and surgical stages were described with a view to other clinicians replicating this technique[59]

Another complicating factor in dental autotransplantation may be the limitations of the recipient site anatomy. In circumstances such as the case reported here, the tooth was lost at the recipient site some time before the transplant was undertaken. Hence, alveolar necking developed at the recipient site. The effect of this, on reducing transplantation success rates, has been observed in a study of 259 transplanted teeth. 1The study found that a 2.5 months or greater delay in transplantation to the edentulous site caused a significant reduction in the success rate, although the vast majority of cases studied were adults.

It was hypothesised that the affected recipient sites had undergone alveolar atrophy to leave a narrow alveolar ridge. In turn this potentially complicates surgery due to the need for additional preparation of the recipient site. Arguably, any reduction in the donor tooth's extra oral time will help in such circumstances, and this was achieved in the case reported here by the use of the customised analogue tooth.

The conventional tooth implantation technique involves extraction of the donor tooth and subsequent use of this tooth to prepare the size and shape of the recipient site, with the aim of achieving a close fit between the root and alveolar bone socket. However, there are two key problems with this technique: the duration of extra-oral (extraction to final implantation) time for the donor tooth; and injury to the periodontal tissues of the donor tooth during the repeated try-ins into the recipient socket. Iatrogenic injuries to the root may significantly affect the viability of the donor tooth's periodontal ligament cells and consequently lead to root resorption and/or ankylosis. On the other hand, an optimal proximity of the root surface to the recipient site bone surface may optimise the blood supply and hence healing of the periodontal ligament cells , which in turn may increase the success rate of autoimplantation[26]

There has been a widespread application of 3D imaging and printing technologies in recent years throughout dentistry. This has resulted in the ability to fabricate 3D printed versions of many orthodontic appliances and

orthognathic wafers . It should therefore be unsurprising that this approach can be utilised for tooth autotransplantation Shahbazian undertook vitro studycomparing the dimensions of stereolithographically printed plastic teeth with the corresponding real teeth. They found that 79% of the surface points analysed were within 0.25 mm accuracy, indicating that the printed teeth were sufficiently similar to the real ones for clinical use. Aside from possible shrinkage or distortion of the printed plastic, the errors may have also been due to the relatively low resolution of the CBCT scans used[41]

This demands meticulous preparation of the recepient site .Conventionally, tooth to be implanted is extracted and then the socket is prepared.this will increase the;

1) procedure time

2) extraalveolar time of donor tooth

3) number of attempts aided to achieve for good fit.

4) surgeon surgical planing intraoperatively.

This condition may leads to poor prognosis of the autoimplanted donor tooth in new alveolar socket.

To overcome these conditions 3D printed PMMA replica of donor tooth is printed which functions as a surgical guide in autoimplantation.

This study shows that a 3D-printed replica of the donor tooth allows for hands-on preoperative and intra-operative planning during the autoimplantation procedure **FIG 4**,**10.** The iatrogenic damage to donor tooth by reducing the extra-alveolar time and minimizing the number of fitting attempts during the preparation of a neo-alveolus, enables a quick and easy autoimplantation procedure.

studies show individual manufacturing of drill bits shaped exactly like the donor tooth have been recommended, but the basic readily available various shaped drill bit also can be used with minimal adjustment to procedure with same effect as we have used in our study

The availability of 3D imaging and additive manufacturing technologies has given rise to many improving techniques in dentistry and oral surgery. This includes CAD CAM manufacturing of crowns and bridges, computer-assisted surgical planning of mandibular reconstruction and orthognathic surgery, and the manufacturing of individualised maxillofacial implants. However, rapid prototyping to facilitate autoimplantation of teeth is new The use of an individually designed tooth replica to facilitate autoimplantation has several important advantages , The one such advantage is that it **helps in virutual planning of recepient site by placing the printed tooth in recepient site and evaluating surgical prepartion which reduces the procedure time, It minimizes the number of fitting attempts that have to be made to achieve a good fit of the donor tooth in the newly prepared**

socket FIG.7. The extra-alveolar time is reduced, which can only improve the status of prognosis of tooth. A replica of the donor tooth furthermore makes the procedure safer for the patient and easier for the surgeon because exact individualised planning of the autoimplantation is possible with this surgical guide even when intra-operative modifications are necessary.

An alternative for an individualised 3D-printed replica of the donor tooth is the use of predesigned surgical templates of premolars. Such a surgical template that is not patient-specific can be sterilised and re-used in subsequent autotransplantation procedures. However, in this study, we chose to use an individualised patient specific 3D-printed replica of the donor tooth. This ensures a good fit of the donor tooth in the neo-alveolus, without the risk of complicating the procedure due to discrepancies between a 'generic' surgical template and the actual donor tooth **FIG 8.**

In summary, we believe that in the future, the autoimplantation of teeth will include using a surgical guide as an alternative for the donor tooth when preparing the neo alveolus. Nevertheless, possible disadvantages should also be considered. For the manufacture of an individualised replica of the donor tooth, a CT scan of the donor tooth is performed. The use of ionising radiation should be justifiable for each specific patient and should be limited[19] Therefore, we performed a selective CT scan focused on the donor tooth with the smallest field of view possible. The radiation load was kept as minimal as possible. The selective CT scan not only enables the manufacture of the

surgical guide, but it also allows the surgeon to carefully plan the extraction of the donor tooth. The CT scan facilitates a shorter and easier surgical procedure, which in turn could minimize the chance of complications and is beneficial for the patient. We therefore believe this limited amount of additional ionising radiation is appropriate. Manufacturing of a replica of the donor tooth is furthermore associated with additional costs. We believe this can be compensated by the fact that the surgical guide shortens the surgical time and because higher success and survival rates could prevent expensive treatments in the future Therefore, several aspects are important in order to maximise the chance of success after autoimplantation. Extraction of the donor tooth should be performed atraumatically the extra-alveolar time should be minimized as much as possible,Iatrogenic damage during implantation at the recipient site should be prevented by minimizing the number of attempts of fitting the donor tooth in the neo-alveolos.After successful implantation,the donor tooth should be fixed in infra-occlusion to prevent postoperative occlusal forces

This study aimed to evaluate our autoimplantation technique using a 3D-printed replica of the donor tooth. Therefore, we reported the technical and intra-operative characteristics of the procedure. In the future, long-term evaluation of the implanted teeth will be necessary to evaluate the success and survival of teeth that were transplanted with the help of this surgical guide.

Summary and Conclusion

SUMMARY AND CONCLUSION

Selection of the optimal donor tooth and surgical procedure for reducing the damage of its periodontal ligament are essential for successful autotransplantation. Prior to autotransplantation,CT images and the 3D virtual simulation program helped recognise the risk anatomic structures, select the compatible donor tooth and predict the surgical process before surgery. During the autotransplantation, the anatomic knowledge by simulation and CARP model could reduce the extra-oral time,number of attempts,surgeons intraoperative time and consequent damage to the periodontal ligament cells of donor teeth. The effective use of 3D technology can be helpful to improve the prognosis of autotransplantation, Recepient socket preparation is bit difficult for multirooted tooth

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